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Los Angeles Department of Water & Power

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May 15, 2015

Ms. Barbara Evoy, Deputy Director
Division of Water Rights
State Water Resources Control Board
1001 I Street, 14th Floor
Sacramento, California 95814

Dear Ms. Evoy:

Subject: Compliance with State Water Resources Control Board (SWRCB) Order Nos. 98-05 and 98-07 (Orders)

Pursuant to SWRCB Decision 1631 and Orders, and in accordance with the terms and conditions of the Los Angeles Department of Water and Power (LADWP) Mono Basin Water Right License Nos. 10191 and 10192, enclosed is a submittal entitled "Compliance Reporting", which contains the following four reports required by Orders. Reports are as follows:

- Mono Basin Operations: Runoff Year (RY) 2014-2015 and planned operations for RY 2015-2016.
- Mono Basin Fisheries Monitoring Report: Rush, Lee Vining, Parker, and Walker Creeks for RY 2014-2015
- Investigating Methodologies for Assessing Woody Riparian Vigor for RY 2015-2016
- Mono Basin Waterfowl Habitat and Population Monitoring for RY 2014-2015

In addition to these reports, submittal also includes Section 1: Status of Restoration Compliance Report (SORC Report) for RY 2014-2015, which summarizes the status of LADWP's compliance activities in Mono Basin to date and planned activities for the upcoming runoff year.

Filing of these reports, along with the restoration and monitoring performed by LADWP in Mono Basin, fulfills LADWP's requirements for RY 2014-2015, as set forth in Decision 1631 and Orders.

Electronic copies of the report will be provided on compact disc to the interested parties listed on the enclosed mailing list. Hard copies of the report for you and your staff will be mailed shortly.

If you have any questions, please contact Mr. Peter N. Tonthat, Civil Engineering Associate, at (213) 367-1792.

Sincerely,

Richard F. Harasick
Director of Water Operations

PNT:jem
Enclosures
c/enc: Mr. Peter N. Tonthat

Mono Basin Distribution List
Runoff Year 2014-2015

Ms. Barbara Evoy Division of Water Rights State Water Resources Control Board 1001 I Street, 14th Floor Sacramento, CA 95814	Ms. Lisa Cutting Mono Lake Committee P.O. Box 29 Lee Vining, California 93541
Ms. Katherine Mrowka Division of Water Rights State Water Resources Control Board 1001 I Street, 14th Floor Sacramento, CA 95814	Board of Supervisors Mono County P.O. Box 715 Bridgeport, California 93517
Mr. Greg Brown Division of Water Rights State Water Resources Control Board 1001 I Street, 14th Floor Sacramento, CA 95814	Mr. Mark Drew California Trout Inc. P.O. Box 3442 Mammoth Lakes, CA 93546
Dr. William Trush Humboldt State University River Institute c/o Dept of Environmental Science & Mgmt 1 Harpst Street Arcata, CA 95521-8299	Mr. Richard Roos-Collins Water and Power Law Group 2140 Shattuck Avenue, Suite 801 Berkeley, CA 94704-1229
Mr. Ross Taylor 1254 Quail Run Court McKinleyville, CA 95519	Mr. Marshall S. Rudolph Mono County Counsel P.O. Box 2415 Mammoth Lakes, CA 93546
Mr. Jon C. Regelbrugge USDA Forest Service P.O. Box 148 Mammoth Lakes, CA 93546	Mr. Steve Parmenter Department of Fish and Wildlife 407 West Line Street, #8 Bishop, CA 93514
Ms. Tamara Sasaki California Department of Parks and Recreation P.O. Box 266 Tahoma, CA 96142	Mr. Doug Smith Grant Lake Reservoir Marina P.O. Box 21 June Lake, CA 93529
Mr. Matthew Green State Parks 3415 Hot Springs Road Markleeville, CA 96120	

In Response to the
State Water Resources Control Board
Order Nos. 98-05 and 98-07

COMPLIANCE REPORTING

Mono Basin Operations
Fisheries Monitoring
Waterfowl Monitoring

May 2015
Los Angeles Department of Water and Power

CONTENTS

Section 1

Status of Restoration Compliance Report

Status of Restoration Compliance Report (SORC)

Compliance with State Water Resources Control Board
Decision 1631 and Order Nos. 98-05 and 98-07

May 2015

Los Angeles Department of Water and Power

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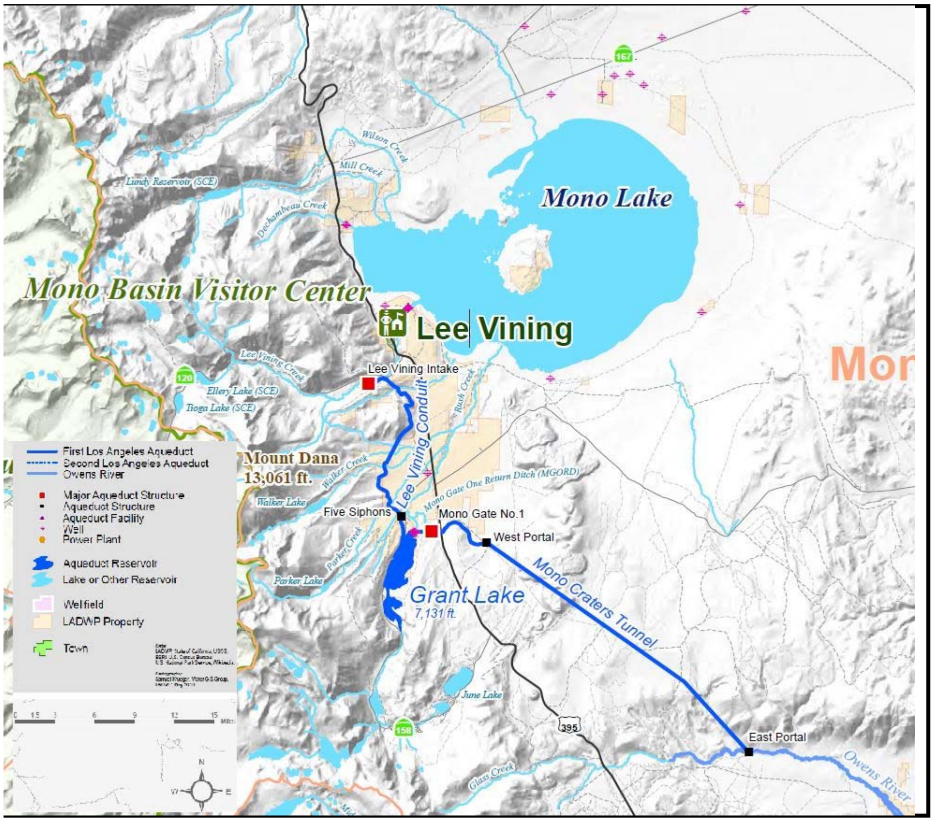
Introduction

Pursuant to State Water Resources Control Board (SWRCB) Decision 1631 and Order Nos. 98-05 and 98-07 (Orders), the Los Angeles Department of Water and Power (LADWP) is to undertake certain activities in the Mono Basin to be in compliance with the terms and conditions of its water right licenses 10191 and 10192. In particular, the Orders state that LADWP is to undertake activities to monitor stream flows, and to restore and monitor the fisheries, stream channels, and waterfowl habitat. This chapter includes the Status of Restoration Compliance Report, which summarizes the status of LADWP compliance activities in the Mono Basin to date. It is expected that the Water Board will approve the Mono Basin Settlement Agreement and amend LADWP's water rights license. Following SWRCB adoption of the amended license, the new requirements will be reflected in future SORC Reports.

Figure 1: Map of Mono Basin showing major Streams and LADWP facilities.



Status of Restoration Compliance Report

This document was first submitted as draft to the interested parties on April 1, 2015. It was developed to include a 21 day review period during which LADWP will review and address comments submitted by the interested parties. Following the 21 day review period, LADWP will finalize it as part of the May 2015 Status of Restoration Compliance Report as below.

Status of Restoration Compliance Report
State Water Resource Control Board Decision 1631 and Order Nos. 98-05 & 98-07

The Status of Restoration Compliance Report (“SORC Report”) is organized into the following sections:

1. **Introduction** – Description of the SORC Report
2. **Definitions** – Explanations of what each category represents
3. **Updates from Previous SORC Report** – Changes over the past year
4. **Plans for the Upcoming Runoff Year** – Planned activities for the upcoming year
5. **Requirements** – Categories of the entire list of LADWP’s requirements in the Mono Basin
6. **Completion Plans** – Long term plans for completing all requirements
7. **Ongoing Items Definitions** – Ongoing activities necessary for LADWP operations in the Mono Basin.

1. Introduction:

The SORC Report details the status of the Los Angeles Department of Water and Power’s (LADWP) restoration requirements in the Mono Basin as outlined by the State Water Resources Control Board (SWRCB) Decision 1631 and Order Numbers 98-05 and 98-07, and any subsequent decision letters distributed by the SWRCB.
This initial structure and content of the SORC report was cooperatively prepared by LADWP and the Mono Lake Committee (MLC) through an extensive series of staff discussions and a workshop held in the Mono Basin in August 2005. LADWP and MLC believe this report represents the most thorough and complete listing of Mono Basin restoration requirements and their current status available in a unified document. These requirements are categorized as ongoing, complete, in progress, incomplete or deferred as defined below in Section 2. The final section of the SORC Report details how LADWP plans to proceed with those items not listed as ongoing or completed (i.e. items in progress, incomplete, and/or deferred).

The SORC Report will be submitted by LADWP to SWRCB as part of the annual Compliance Reporting. The original SORC Report was distributed to the SWRCB and the "interested parties[1]" on January 11, 2007. The second was distributed on May 15, 2007. LADWP will update the SORC Report annually with input from the interested parties. By April 1 each year, LADWP will update and submit a draft SORC Report to the interested parties. Within 21 days of the draft submission, LADWP will accept comments on the draft SORC Report from the interested parties. Then, LADWP will finalize the SORC Report, incorporating and/or responding to comments. The final SORC Report will then be included into the final Compliance Reporting to SWRCB by May 15 of each year.

It is expected that the Water Board will approve the Mono Basin Settlement Agreement and amend LADWP's water rights license. The new requirements are expected to take effect immediately after the Water Board issues an order, and those new requirements will be reflected in future SORC Reports. Any items no longer relevant under the new order will be moved to a new category "Eliminated" in the SORC. The new SORC will show both a new numbering system for all active items as well as the old numbering system for cross reference. Once agreement is reached on the items in the "eliminated" category, those items as well as the old numbering will no longer be shown in future SORC Reports.

2. Definitions:

Below are the definitions of the categories where each requirement has been grouped.

A.	<u>Ongoing</u>	Items that are current and require continuous action (e.g. Maintain road closures in floodplains of Rush and Lee Vining Creeks)
B.	<u>Complete</u>	Items that have been finalized (e.g. Rehabilitation of the Rush Creek Return Ditch)
C.	<u>In-Progress</u>	Items started and not yet finalized because of time or the timeline extends into the future (e.g. Waterfowl monitoring and reporting)
D.	<u>Incomplete</u>	Items not yet started or not complete because plans for completion not finalized.
E.	<u>Deferred</u>	Items placed on hold which need input from the Stream Scientists and/or SWRCB before plans commence (e.g. Prescribed burn program)

3. Updates from Previous SORC Report:

Since the last SORC Report of May 15, 2014, there have been changes in the report, and those are outlined below.

- Section 4, Plans for the Upcoming Runoff Year, has been updated to cover Runoff Year 2015-2016 (RY 2015-16).
- Section 5, In-Progress Item C4, "Grant Lake Operation Management Plan (GLOMP)", will be replaced with "Mono Basin Operations Plan (MBOP)", once the

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[1] The "interested parties" include those parties involved in SWRCB Decision 1631, the Mono Basin Settlement Agreement, SWRCB Order Nos. 98-05 and 98-07, and others who have, or may, similarly involve themselves in the Mono Basin restoration activities required by SWRCB.

SWRCB approves the Settlement Agreement and issues a new amended Water Rights license. The “Mono Basin Operations Plan” will contain products of the Settlement Agreement.

- Section 5, Completed Item B14 moved to Category E “Deferred Items”. Rehabilitation of the Rush Creek Return Ditch.
- Section 5, Completed Items B27 and B28 moved to Category E “Deferred Items”. Rewatering of Rush Creek side channel 1A in reach 4A and assessing the need to revegetate the areas affected by the side channel openings.
- Section 5, Completed Items B32 and B33 moved to Category E “Deferred Items”. Rewatering of Rush Creek side channel 4Bii in reach 4B and assessing the need to revegetate the areas affected by the side channel openings.
- Section 5, In-Progress Item C8 moved to Category E “Deferred Items”. Stream monitoring for 8-10 years to inform peak flow evaluation and recommendations including the need for a Grant Lake Reservoir Outlet.

4. Plans for the Upcoming Runoff Year:

During the upcoming runoff year, RY2015-16, LADWP plans to:

1. Continue with all requirements listed under Category A – Ongoing Items, as needed based on the runoff year.
2. Continue with Category C – In-Progress Item C13 “Riparian and Lake Fringing wetland vegetation monitoring and reporting” (which includes the survey of springs around Mono Lake), which is done every 5 years
3. Continue Category C – In-Progress Items C17 “Sediment Bypass for Parker Creek”. Sediment bypass will continue in the next non-Dry RY.
4. Continue Category C – In-Progress Items C18 “Sediment Bypass for Walker Creek”. Sediment bypass will continue in the next non-Dry RY.
5. Continue Category A – Ongoing Item A16 – “Aerial Photography*”.* LADWP will capture aerial and/or satellite imagery of the Mono Basin.

5. Requirements:

This section lists and categorizes the individual requirements based on the status of each item. The requirements are derived from SWRCB Decision 1631, and/or Order Nos. 98-05 and 98-07, and/or any subsequent decision letters distributed by SWRCB. The requirements are either described in the cited section of the order and/or are described in the cited page of the specified plan and/or document (Stream Plan, Waterfowl Plan, GLOMP, etc.) that the Order references, and/or detailed in the SWRCB letter. Plans for completing in-progress, incomplete, and deferred items are further explained in Section 6, Completion Plans. Finally, plans for those items described as ongoing are detailed in Section 7, Ongoing Items Description.

Category A – Ongoing Items

1. Maintain road closures in floodplains of Rush and Lee Vining Creeks – *Stream Work*
   Order 98-05 order 1; Stream Plan p. 71-75

2. Base flow releases – *Stream Management*
   Order 98-05 order 2.a.; GLOMP p. 2, table A

3. Low winter flow releases – *Stream Management*
   Order 98-05 order 2.b.

4. Annual operations plan – *Stream Management*
   Order 98-05 order 3; GLOMP p. 103, 104

5. Notification of failure to meet required flows – *Stream Management*
   Order 98-05 order 3

6. Grant operations and storage targets – *Stream Management*
   Order 98-05 order 1.a.; Decision 1631 order 1; GLOMP p. 84

7. Amount and pattern of export releases to the Upper Owens River – *Stream Management*
   Order 98-05 order 2; Decision 1631 order 7; GLOMP p. 84, 85

8. Diversion targets from streams – *Stream Management*
   Order 98-05 order 2; GLOMP p. 85

9. Export amounts dependent on Mono Lake level – *Stream Management*
   Decision 1631 order 6

10. Year type designation and guidelines – *Stream Management*
    Order 98-05 order 2; Decision 1631 order 3; GLOMP p. 87-96

11. Dry and wet cycle contingencies for stream restoration flows and base flows – *Stream Management*
    Order 98-05 order 2; GLOMP p. 97

12. Deviations from Grant Lake Operation Management Plan (GLOMP) – *Stream Management*
    Order 98-05 order 2; GLOMP p. 98, 99

13. Ramping rates – *Stream Management*
    Order 98-05 order 2; Decision 1631 order 2; GLOMP p. 90-96

14. Stream restoration flows and channel maintenance flows – *Stream Management*
    Order 98-05 order 1.a.

15. Salt Cedar eradication – *Waterfowl*

Order 98-05 order 4.e.; Waterfowl Plan p. 27

16. Aerial photography every five years or following an extreme wet year event – *Monitoring*
    Order 98-05 order 1.b; Stream Plan p. 103

17. Make basic data available to public – *Monitoring*
    Order 98-05 order 1.b as revised by Order 98-07; Order 98-07 order 1.b(2); Stream Plan p. 110

18. Operation of Lee Vining sediment bypass – Stream Facility Modifications
    Order 98-05 order 2

19. Operation of the Rush Creek augmentation from the Lee Vining Conduit when necessary – *Stream Management*
    Order 98-05 order 2

20. Make data from all existing Mono Basin data collection facilities available on an internet web site on a same-day basis – *Stream Management*
    Order 98-05 order 2.c

Category B – Completed Items

1. Placement by helicopters of large woody debris into Rush Creek, completed fall 1999 – *Stream Work*
   Order 98-05 order 1; order 1.d.; Stream Plan p. 67, 68

2. Placement by helicopters of large woody debris into Lee Vining Creek, completed fall 1999 – *Stream Work*
   Order 98-05 order 1; order 1.d.; Stream Plan p. 67, 68

3. Rewater Rush Creek side channels in reach 3A, completed fall 1999 – *Stream Work*
   Order 98-05 order 1; Stream Plan p. 68-71

4. Rewater Rush Creek side channel in reach 3B, completed fall 1999 with changes (see LADWP annual Compliance Reporting, May 2000) – *Stream Work*
   Order 98-05 order 1; Stream Plan p. 68-71

5. Rewater Rush Creek side channel in reach 3D, completed fall 2002 with changes (see LADWP annual Compliance Reporting, May 2003) – *Stream Work*
   Order 98-05 order 1; Stream Plan p. 68-71

6. Revegetate approximately 250 Jeffrey Pine trees on Lee Vining Creek, completed in 2000 – *Stream Work*
   Order 98-05 order 1; Stream Plan p. 71-75

7. Revegetate willows on Walker Creek. No planting necessary in judgment of LADWP and MLC as area revegetated rapidly without intervention – *Stream Work*

Order 98-05 order 1; Stream Plan p. 71-75

8. Revegetate willows on Parker Creek. No planting necessary in judgment of LADWP and MLC as area revegetated rapidly without intervention – *Stream Work*
Order 98-05 order 1; Stream Plan p. 71-75

9. Limitations on vehicular access in Rush and Lee Vining Creek floodplains, completed fall 2003 – *Stream Work*
Order 98-05 order 1; Stream Plan p. 78-80

10. Removal of bags of spawning gravel, completed fall 2003 – *Stream Work*
Order 98-05 order 1; Stream Plan p. 85, 86

11. Removal of limiter logs, completed 1996 – *Stream Work*
Order 98-05 order 1; Stream Plan p. 86

12. Removal of Parker Plug, completed by California Department of Transportation 2000 – *Stream Work*
Order 98-05 order 1; Stream Plan p. 87

13. Sediment bypass facility for Lee Vining Creek, completed winter 2005 – *Stream Facility Modifications*
Order 98-05 order 1.f.

14. Flood flow contingency measures, completed by California Department of Transportation's Highway 395 improvements in 2002 – *Stream Management*
Order 98-05 order 1; Stream Plan p. 76

15. Stream monitoring site selection, completed 1997 – *Monitoring*
Order 98-05 order 2; Stream Plan p. 109

16. Waterfowl and limnology consultants, completed 2004 – *Monitoring*
Order 98-05 order 4; Waterfowl Plan p. 27-29

17. Status report on interim restoration in Mono Basin, completed 2006 – *Other*
Decision 1631 order 8.d (3)

18. Cultural resources investigation and treatment plan report to SWRCB, completed 1996 – *Other*
Decision 1631 order 9, 10

19. Revegetate or assess the need to revegetate Rush Creek side channels in reach 3A five years after rewatering, assessed annually and reported in May 2006 Monitoring Report – *Stream Work*
Order 98-05 order 1; Stream Plan p. 71-75

20. Revegetate or assess the need to revegetate Rush Creek side channels in reach 3B five years after rewatering, assessed annually and reported in May 2006 Monitoring Report – *Stream Work*
    Order 98-05 order 1; Stream Plan p. 71-75

21. Revegetate or assess the need to revegetate Rush Creek side channel in reach 3D and reported in May 2008 Monitoring Report – *Stream Work*
    Order 98-05 order 1; Stream Plan p. 71-75

22. Rewater Rush Creek side channel 11 in reach 4C. Final review was conducted by the Stream Scientists. After presentation of the final review, LADWP followed the recommendations of the Stream Scientists not to do any action on the channel. This item is now approved by SWRCB and is therefore considered completed in 2008. – *Waterfowl*
    Order 98-05 order 4.a., order 4.d.; Waterfowl Plan p. 22

23. Rewater Rush Creek side channel 14 in reach 4C. Final review was conducted by the Stream Scientists. After presentation of the final review, LADWP followed the recommendations of the Stream Scientists not to do any action on the channel. This item is now approved by SWRCB and is therefore considered complete in 2008. – *Stream Work*
    Order 98-05 order 1; Stream Plan p. 68-71

24. Revegetate or assess the need to revegetate Rush Creek side channel 11 in reach 4C for five years following rewatering. LADWP followed the recommendations of the Stream Scientists not to do any action on the channel. This item is now approved by SWRCB and is therefore considered completed in 2008. – *Waterfowl*
    Order 98-05 order 4.a., order 4.d.; Waterfowl Plan p. 22

25. Revegetate or assess the need to revegetate Rush Creek side channel 14 in reach 4C for five years after rewatering. LADWP followed the recommendations of the Stream Scientists not to do any action on the channel. This item is now approved by SWRCB and is therefore considered completed in 2008. – *Stream Work*
    Order 98-05 order 1; Stream Plan p. 68-71

26. LADWP and MLC were to cooperatively revegetate pine trees on areas of Rush Creek and Lee Vining Creek including disturbed, interfluve, and upper terrace sites targeted from reach 3B through 5A on Rush Creek. In 2005, remaining suitable areas were assessed resulting in a map showing those areas where planting pine trees may be successful and would add to habitat complexity. LADWP and MLC investigated locations suitable for planting by LADWP and MLC staff and volunteers. Acceptable Jeffrey Pine seedlings were procured by LADWP and were planted by MLC and volunteers on all available suitable sites. This item is considered complete and is moved to Category B "Completed Items." However, MLC may continue to water these seedlings. MLC may also plant cottonwoods with volunteers as opportunities arise – Stream Work Order 98-05 order 1; Stream Plan p. 71-75

27. Rewater Rush Creek side channel 4Bii in reach 4B, completed March 2007 – *Stream Work.* The rewatering of Rush Creek side channel 4Bii in reach 4B was deferred by the Stream Scientists. Final review was conducted by McBain and Trush. After presentation of the final review, LADWP followed the recommendations of the Stream Scientists and SWRCB has approved the plan. *Order 98-05 order 1; Stream Plan p. 68-71*

28. Rewater Rush Creek side channel 8 in reach 4B, completed March 2007 – *Waterfowl.* The further rewatering of Rush Creek side channel complex 8 in reach 4B was deferred by the Stream Scientists. Final review is being conducted by McBain and Trush. After presentation of the final review, LADWP followed the recommendations of the Stream Scientists and SWRCB has approved the plan *Order 98-05 order 4.a., order 4.d; Waterfowl Plan p. 22*

<u>Category C – In-Progress Items</u>

1. Placement by hand crews of large woody debris into Rush Creek on an opportunistic basis based on stream monitoring team recommendations – *Stream Work*
   Order 98-05 order 1; order 1.d.; Stream Plan p. 67, 68

2. Placement by hand crews of large woody debris into Lee Vining Creek on an opportunistic basis based on stream monitoring team recommendations – *Stream Work*
   Order 98-05 order 1; order 1.d.; Stream Plan p. 67, 68

3. Grazing moratorium for 10 years, assessed annually and status reported in May 2009 Monitoring Report. Grazing moratorium to continue until further notice. – *Stream Management*
   Order 98-05 order 1; Stream Plan p. 83

4. Grant Lake Operation Management Plan (GLOMP) preparation for revisions – *Stream Management*
   Order 98-05 order 2; GLOMP p. 103, 104

5. Waterfowl project funding – *Waterfowl*
   Order 98-05 order 4.b.

6. Salt Cedar eradication reporting– *Waterfowl*
   Order 98-05 order 4.e.; Waterfowl Plan p. 27

7. Stream monitoring team to perform duties – *Monitoring*
   Order 98-05 order 1.b as revised by Order 98-07

8. Stream monitoring reporting to the SWRCB – *Monitoring*
   Order 98-05 order 1.b as revised by Order 98-07; Order 98-07 order 1.b(2); Stream Plan p. 110

9. Development, approval, and finalization of stream monitoring termination criteria for

Walker and Parker Creeks – *Monitoring Order 98-07*

10. Development, approval, and finalization of stream monitoring termination criteria for Lee Vining and Rush Creeks – *Monitoring*
    Order 98-07

11. Hydrology monitoring and reporting – *Monitoring*
    Order 98-05 order 4; Waterfowl Plan p. 27

12. Lake limnology and secondary producers monitoring and reporting – *Monitoring*
    Order 98-05 order 4; Waterfowl Plan p. 27, 28

13. Riparian and Lake fringing wetland vegetation monitoring and reporting – *Monitoring*
    Order 98-05 order 4; Waterfowl Plan p. 27, 28

14. Waterfowl monitoring and reporting – *Monitoring*
    Order 98-05 order 4; Waterfowl Plan p. 28; LADWP's 2004 "Mono Lake Waterfowl Population Monitoring Protocol" submitted to SWRCB on October 6, 2004

15. Testing the physical capability for Rush Creek augmentation up to 150 cfs from the Lee Vining Conduit through the 5-Siphon Bypass facility – *Stream Management*
    Order 98-05 order 2; GLOMP p. 82, 83

16. Evaluation of the effects on Lee Vining Creek of Rush Creek augmentation for diversions up to 150 cfs through the Lee Vining Conduit – *Monitoring*
    Order 98-05 order 1.b.

17. Sediment bypass for Parker Creek – *Stream Facility Modifications*
    Order 98-05 order 1.f.

18. Sediment bypass for Walker Creek – *Stream Facility Modifications*
    Order 98-05 order 1.f.

Category D – Incomplete Items

None

Category E – Deferred Items

1. Recommend an Arizona Crossing or a complete road closure at the County Road Lee Vining Creek, if and when Mono County plans to take action – *Stream Work*
   Order 98-05 order 1; Stream Plan p. 78-80

2. Fish screens on all irrigation diversions – *Stream Facility Modifications*
   Order 98-05 order 1; Stream Plan p. 84

3. Rehabilitation of the Rush Creek Return Ditch, completed 2002 – *Stream Facility Modifications*
   Order 98-05 order 1, order 1.c.; Stream Plan p. 85, appendix III

4. Prescribed burn program – *Waterfowl*
   Order 98-05 order 4.b.(3)c.; Waterfowl Plan p. 25, 26

5. Rewatering of Rush Creek side channel 1A in reach 4A.– *Stream Work*
   Order 98-05 order 1; Stream Plan p. 68-71

6. Assessing the need to revegetate the areas affected by the side channel openings for Rush Creek side channel 1A in reach 4A – *Stream Work; Order 98-05 order 1; Stream Plan p. 68-71*

7. Assessing the need to revegetate the areas affected by the side channel openings for Rush Creek side channel 4Bii in reach.

8. Assessing the need to revegetate the areas affected by the side channel openings for Rush Creek side channel 8 in reach 4B.

9. Stream monitoring for 8-10 years to inform peak flow evaluation and recommendations including the need for a Grant Lake Reservoir Outlet – *Monitoring*
   Order 98-05 order 1.b as revised by Order 98-07

6. Completion Plans:

The following descriptions detail how LADWP plans to fulfill SWRCB requirements in the Mono Basin for each item above not categorized as complete or ongoing. This section will be reviewed annually by LADWP for revisions to reflect progress towards completion.

Category C – In-Progress Items

Item C1 – During walking surveys, large woody debris will be placed into Rush Creek and will continue to be done on an opportunistic basis based on recommendations made by the Monitoring Team. This item will remain “In-Progress” until the Monitoring Team indicates that no further work is required. At that time, this item will be considered complete and will be moved to Category B “Completed Items”.

Item C2 – During walking surveys, large woody debris will be placed into Lee Vining Creek and will continue to be done on an opportunistic basis based on recommendations made by the Monitoring Team. This item will remain “In-Progress” until the Monitoring Team indicates that no further work is required. At that time, this item will be considered complete and will be moved to Category B “Completed Items”.

Item C3 – The grazing moratorium in the Mono Basin was in effect until 2009. At this time LADWP does not intend to allow grazing on its lands in the Mono Basin and will continue the moratorium in 2015. This item will remain in the Category C "In Progress".

Item C4 – The Grant Lake Operation Management Plan (GLOMP) includes instructions to "review for revisions" every five years until Mono Lake reaches 6,391 feet above mean sea level. Although no revisions have been finalized to date, the plan was continuously under review. GLOMP is expected to be revised and replaced with "Mono Basin Operations Plan" (MBOP) after the SWRCB approves the Settlement Agreement and amends LADWP Water Rights licenses. This item will remain in Category C "In-Progress Items" until the final operation/management plan is approved by SWRCB. It is expected that a final plan will be developed after the Water Board order. Once the plan is approved, this item will be considered complete and will be moved to Category B "Completed Items".

Item C5 – LADWP is to make available a total of $275,000 for waterfowl restoration activities in the Mono Basin. This money was to be used by the USFS if they requested the funds by December 31, 2004. Afterwards, any remaining funds are to be made available to any party wishing to do waterfowl restoration in the Mono Basin after SWRCB review. USFS has requested funds for a project estimated at $100,000. MLC has requested that the remainder of the funds be applied toward the total cost of the Mill Creek Return Ditch upgrade which would provide benefits for waterfowl habitat. The Mill Creek Return Ditch rehabilitation is a component of a Federal Energy Regulatory Commission (FERC) settlement agreement. These funds will continue to be budgeted by LADWP until such a time that they have been utilized. Currently, this money has been tentatively been included in the Settlement Agreement as part of Administrative of Monitoring Accounts to be administered by a Monitoring Administration Team (MAT). Once the full $275,000 has been utilized, this item will be considered complete and will be moved to Category B "Completed Items".

Item C6 – Progress of the salt cedar eradication efforts is reported in the annual reports following the vegetation monitoring efforts. This was reported in the May 2010 Monitoring Report. This item will continue to be in progress until notice from SWRCB is received that LADWP's obligation for this in the Mono Basin is complete. Once this notice is received, this item will be moved to Category B "Completed Items".

Item C7 – The stream monitoring team continues to perform their required duties in the Mono Basin. This item will continue to be in progress until notice from SWRCB is received that LADWP's obligation for funding and managing the monitoring team in the Mono Basin is complete. Once this notice is received, this item will be moved to Category B "Completed Items", and LADWP will implement an appropriate monitoring program for the vegetation, stream morphology waterfowl, and fisheries.

Item C8 – Progress of the restoration efforts is reported in the annual reports. This item will continue to be in progress until notice from SWRCB is received that LADWP's obligation for this in the Mono Basin is complete. Once this notice is received, this item will be moved to Category B "Completed Items".

Item C9 – The Stream Scientists have submitted final recommendations for termination criteria on Walker and Parker Creeks in 2007 to the SWRCB. There has been no decision from SWRCB. Once the termination criteria are finalized by the Stream Scientists and approved by SWRCB, this item will be considered complete and will be moved to Category B “Completed Items”.

Item C10 – The Stream Scientists have submitted final recommendations for termination criteria on Lee Vining and Rush Creeks in 2007 to the SWRCB. There has been no decision from SWRCB. Once approved by SWRCB, this item will be considered complete and will be moved to Category B “Completed Items”.

Item C11 – LADWP will continue to monitor and report on the hydrology of the Mono Basin including regular Mono Lake elevation readings, stream flows, and spring surveys until SWRCB approves that all or portions of the hydrology monitoring is no longer required. Once this occurs, all or portions of this item will be considered complete and will be moved to Category B “Completed Items”. Any portions of this requirement that are deemed to be ongoing by the SWRCB will be moved to Category A “Ongoing Items”.

Item C12 – LADWP will continue to monitor and report on the Mono Lake limnology and secondary producers until SWRCB approves that limnological monitoring is no longer required. Once this occurs, this item will be considered complete and will be moved to Category B “Completed Items”.

Item C13 – LADWP will continue to monitor and report on the vegetation status in riparian and lake fringing wetland habitats, which is done every 5 years until SWRCB approves that vegetation monitoring is no longer required. Once this occurs, this item will be considered complete and will be moved to Category B “Completed Items”.

Item C14 – LADWP will continue to monitor and report on the waterfowl populations in the Mono Basin until SWRCB approves that waterfowl monitoring is no longer required. Once this occurs, this item will be considered complete and will be moved to Category B “Completed Items”.

Item C15 – Testing augmentation of Rush Creek flows with water from Lee Vining Creek through the use of the Lee Vining Conduit is possible and can occur as needed as demonstrated during peak runoff in June 2005. The augmentation has been tested up to 100 cfs and the orders call for maximum augmentation to be 150 cfs. This will only be possible if adequate runoff is available in Lee Vining Creek after the peak operation is complete. Once augmentation is successfully tested through 150 cfs, this item will be moved to Category B “Completed Items”.

Item C16 – Evaluation of the effects of Rush Creek augmentation on Lee Vining Creek needs to be completed to cover diversions up to 150 cfs. Once the evaluation is completed, this item will be moved to Category B “Completed Items”.

Item C17 – Sediment bypass for Parker Creek is now in trial implementation stage. Once a plan is finalized by SWRCB and becomes part of LADWP's operation plans, this item will be moved to Category A "Ongoing Items".

Item C18 – Sediment bypass for Walker Creek is now in trial implementation stage. Once a plan is finalized by SWRCB and becomes part of LADWP's operation plans, this item will be moved to Category A "Ongoing Items".

Category D – Incomplete Items

None

Category E – Deferred Items

Item E1 – Pending further action by Mono County to improve the county road crossing at Lee Vining Creek, LADWP will write a letter to Mono County recommending an Arizona crossing at that point. Once LADWP writes this letter, or the parties agree that this is unnecessary; this item will be moved to Category B "Completed Items".

Item E2 – LADWP was to place fish screens on all of its irrigation diversions in the Mono Basin. Subsequently LADWP ended all irrigation practices and hence does not need to install fish screens. If at a later date LADWP resumes irrigation, fish screens will be installed and this item will be moved to Category A "Ongoing Items".

Item E3 – Rehabilitation of the Rush Creek Return Ditch was completed in 2002. Since then, vegetation growth has slightly reduced ditch capacity. To restore maximum capacity of 380 cfs, the return ditch embankment shall be raised as part of the Grant Lake Spillway Modification Project. Construction of this Project is expected to begin in April of 2017. This item will be moved to Category C "In-Progress Items" upon start of construction.

Item E4 – LADWP began a prescribed burn program with limited success. LADWP requested to remove this item from the requirements and the SWRCB instead ruled that the prescribed burn program will be deferred until Mono Lake reaches 6,391 ft. Once Mono Lake reaches 6,391 ft. LADWP will reassess the prescribed burn. Based on results from the assessment, LADWP will either reinstate the program or request relief from the SWRCB from this requirement. If LADWP reinstates the program this item will be moved to Category C "In-Progress Items", however if LADWP requests, and is granted relief from this SWRCB requirement, this item will be moved to Category B "Completed Items".

Item E5 - Rewatering of Rush Creek side channel 1A in reach 4A. Final review was conducted by the Stream Scientists. After presentation of the final review, LADWP followed the recommendations of the Stream Scientists not to do any action on the channel and was awaiting final decision by SWRCB. This item was approved by SWRCB and was therefore considered completed in 2008. Further work on Channel 1A was to be considered in the future if deemed appropriate. In 2014, as part of the pending new license, it has been included to be done in the future. Until the

SWRCB approves the Settlement Agreement and amends LADWP's license, it will be placed in Category D – "Deferred Item".

Item E6 - Assessing the need to revegetate the areas affected by the side channel openings for Rush Creek side channel 1A in reach 4A will occur for five years following rewatering. LADWP followed the recommendations of the Stream Scientists not to do any action on the channel and was awaiting final decision by SWRCB. This item was approved by SWRCB and was therefore considered completed in 2008. In 2014, as part of the pending new license, it has been included to be done in the future. Until the SWRCB approves the Settlement Agreement and amends LADWP's license, it will be placed in Category D – "Deferred Item".

Item E7 - Assessing the need to revegetate the areas affected by the side channel openings for Rush Creek side channel 4Bii in reach 4B five years following rewatering (2007) occurred in the summer of 2012. The results from the assessment following the fifth year after rewatering was reported in Section 4 of the 2013 report. The final assessment concluded that satisfactory revegetation has occurred through natural processes and was considered complete and was moved to Category B "Completed Items". However, in 2014, as part of the pending new license, it has been included to be done in the future. Until the SWRCB approves the Settlement Agreement and amends LADWP's license, it will be placed in Category D – "Deferred Item".

Item E8 - Assessing the need to revegetate the areas affected by the side channel openings for Rush Creek side channel 8 in reach 4B five years following rewatering (2007) occurred in the summer of 2012. The results from the assessment following the fifth year after rewatering were reported in Section 4 of the 2013 report. The final assessment concluded that satisfactory revegetation has occurred through natural processes and was considered complete and was moved to Category B "Completed Items". However, in 2014, as part of the pending new license, it has been included to be done in the future. Until the SWRCB approves the Settlement Agreement and amends LADWP's license, it will be placed in Category D – "Deferred Item".

Item E9 – The stream monitoring team is to evaluate the restoration program after "no less than 8 years and no more than 10 years" from the commencement of the restoration program. This evaluation is to cover the need for a Grant Lake outlet, Rush Creek augmentation, and the prescribed stream flow regime. According to SWRCB Order Nos. 98-05 and 98-07, evaluation of LADWP's facilities to adequately provide proper flows to Rush Creek "*shall take place after two data gathering cycles but no less than 8 years nor more than 10 years after the monitoring program begins*". The Monitoring Team submitted final recommendation, on April 30, 2010. LADWP had 120 days after receiving the recommendation from the monitoring team to determine whether to implement the recommendation of the monitoring team. On July 28, 2010, LADWP submitted a Feasibility Report evaluating the recommendations. In September 2013, LADWP entered into a Settlement Agreement with the Stakeholders and this Agreement is pending SWRCB's approval via an amended Water Rights license. Until the SWRCB approves the Settlement Agreement and amends LADWP's license, it will be placed in Category D – "Deferred Item".

7. Ongoing Items Description:

See Section 5 for references where each requirement originates.

Category A – Ongoing Items

Item A1 – *Road closures*. Periodically LADWP personnel will visit all road closures performed by LADWP in accordance with SWRCB Order No. 98-05, Order 1, in the Lower Rush and Lee Vining Creek areas to assess their effectiveness. Where evidence exists that a road closure is ineffective, LADWP will improve the road closures through means such as additional barriers.

Item A2 – *Base flow releases*. LADWP normally will control flow releases from its facilities into Lower Rush, Parker, Walker, and Lee Vining Creeks according to agreed upon flow rate requirements as set forth in the SWRCB Decision 1631, Order Nos. 98-05 and Order 98-07, the Grant Lake Operations Management Plan, and any subsequent operations plans and decisions made by the SWRCB.

Item A3 – *Low winter flow releases*. Per the California Department of Fish and Wildlife recommendations, and SWRCB Order No. 98-05, order 2.b., LADWP will maintain winter flows into Lower Rush Creek below 70 cfs in order to avoid harming the Rush Creek fishery.

Item A4 – *Annual operations plan*. Per SWRCB Order No. 98-05, order 3, LADWP will distribute an annual operations plan covering its proposed water diversions and releases in the Mono Basin. Presently the requirement is to distribute this plan to the SWRCB and all interested parties by May 15 of each year.

Item A5 – *Notification of failure to meet flow requirements*. Per SWRCB Order No. 98-05, order 3, and SWRCB Decision 1631, order 4, if at the beginning of the runoff year, for any reason, LADWP believes it cannot meet SWRCB flow requirements, LADWP will provide a written explanation to the Chief of the Division of Water Rights by May 1, along with an explanation of the flows that will be provided. If unanticipated events prevent LADWP from meeting SWRCB Order No. 98-05 Stream Restoration Flow requirements, LADWP will notify the Chief of the Division of Water Rights within 20 days and provide a written explanation of why the requirement was not met. LADWP will provide 72 hours notice and an explanation as soon as reasonably possible for violation of SWRCB Decision 1631 minimum instream flow requirements.

Item A6 – *Grant storage targets*. LADWP will operate its Mono Basin facilities to maintain a target storage elevation in Grant Lake Reservoir between 30,000 and 35,000 acre-feet at the beginning and end of the runoff year. LADWP shall seek to have 40,000 acre-feet in Grant Reservoir on April 1 each year at the beginning of wet and extreme wet years.

Item A7 – *Export release patterns to the Upper Owens River*. Per SWRCB Decision 1631, order 7, and SWRCB Order No. 98-05, order 2, LADWP will make exports from the Mono Basin to the Upper Owens River in a manner that will not have a combined flow rate below East Portal above 250 cfs. LADWP will perform ramping of exports at 20% or 10 cfs, whichever is greater, on the ascending limb, and 10% or 10 cfs, whichever is greater, on the descending limb of the hydrograph as measured at the Upper Owens River.

Item A8 – *Diversion targets from streams*. Per the 1996 GLOMP, diversion targets for exports from the Mono Basin will be divided between Rush, Lee Vining, Parker and Walker Creeks in the following manner. During all years except dry and extremely wet years, LADWP will seek to divert one-third to one-half of the export amount from Lee Vining Creek, with the remaining water coming from Rush Creek. Only during dry years when 16,000 acre-feet of export is permitted, LADWP will seek to divert from Parker and Walker Creeks. During extremely wet years, all exports will come from diversions off of Rush Creek. Parker and Walker Creeks are expected to be flow through after the SWRCB approves the Settlement Agreement and amends LADWP Water Rights licenses.

Item A9 – *Export amounts dependent on Mono Lake level*. LADWP export amounts follow those ordered by SWRCB Decision 1631, order 2.

Item A10 – *Year type designation and guidelines*. Per SWRCB Decision 1631, order 4, SWRCB Order No. 98-05, and GLOMP, LADWP will perform runoff year forecasts for the Mono Basin with preliminary forecasts being conducted on February 1, March 1, and April 1, with the forecast being finalized on or around May 1 if necessary. LADWP developed a draft May 1 forecast methodology without a need for May snow surveys. When Gem Pass snow pillow measures show an increase in water content between April 1 and May 1, the percentage change experienced by the pillow will be applied to all of the April 1st snow course survey measurements used in calculating the runoff.

Item A11 – *Dry and wet cycle contingencies for stream restoration flows and base flows*. During consecutive dry years LADWP will release channel maintenance flows (CMF) every other year. The CMF will commence in the second consecutive dry year (which took place in 2013 and takes place again in 2015). The channel maintenance flows for Rush Creek will be 100 cfs for five days, and for Lee Vining Creek it will be 75 cfs for five days. Ramping rates will be 10 cfs per day. The occurrence of a year type other than a dry year will terminate the dry year cycle. During consecutive wet years, LADWP will increase base flows above the minimum flow rate every other year. The increased base flows will commence in the second consecutive wet year. The occurrence of a year type other than a wet year will terminate the wet year cycle.

Item A12 – *Deviations from Grant Lake Operation Management Plan (GLOMP)*. LADWP must maintain operational flexibility to adjust or react to unpredictable circumstances.

Item A13 – *Ramping rates*. LADWP will continue to operate its Mono Basin facilities in order to provide SWRCB ramping flow requirements for Lee Vining, Parker, Walker, and Rush Creeks.

Item A14 – *Stream restoration flows and channel maintenance flows*. LADWP will continue to operate its Mono Basin facilities in order to provide peak flow requirements for Lee Vining, Parker, Walker, and Rush Creeks.

Item A15 – *Salt Cedar eradication*. LADWP will continue assisting in a Mono Basin wide effort to eradicate Salt Cedar (*Tamarisk*), and will continue to report on these efforts.

Item A16 – *Aerial Photography.* LADWP will capture aerial and/or satellite imagery of the Mono Basin (Stream Plan, 1" = 6,000' scale; SWRCB Order No. 98-05, Section 6.4.6(4), 1:6,000 scale) every five years or following an extreme wet year event, which resets the five year clock.

Item A17 – *Make basic data available to public*. Per SWRCB Order 98-05, Order 1.b., as revised by SWRCB Order No. 98-07, order 1.b(2), LADWP will continue to make all basic monitoring data available to the public.

Item A18 – *Operation of Lee Vining sediment bypass*. In order to bypass sediment past the Lee Vining diversion facility, LADWP will operate the Lee Vining Conduit control gate to assist with ramping flows towards peak with the intention of having it be in the completely open position while peak flows are passing the diversion facility. After peak flows have passed the facility, the Lee Vining Conduit control gate will slowly close assisting with ramping flows back down towards base flow condition.

Item A19 – *Operation of the Rush Creek augmentation from the Lee Vining Conduit when necessary*. At times when peak flow requirements in Rush Creek exceed facility capacities, and Grant Lake Reservoir is not spilling, LADWP will operate the Lee Vining Conduit 5-Siphon Bypass to bring water from Lee Vining Creek to Rush Creek to augment flows to the required levels.

Item A20 – Data from existing Mono Basin data collection facilities is available on a same-day basis on the LADWP.com internet web site. The data collection and reporting works, as with any other system, can experience periodic short term communication problems and/or technical difficulties. LADWP will continue to monitor the data posting on a daily basis and will work to troubleshoot and correct problems as soon as possible. LADWP will continue to improve the data collection, computer, and communication systems as new technology(ies) become available.

Section 2

Mono Basin Operations

Section 2

Mono Basin Operations

Compliance with State Water Resources Control Board Decision 1631 and Order Nos. 98-05 and 98-07

May 2015

Los Angeles Department of Water and Power

Table of Contents Page No.

Attachments:

I. Introduction

Pursuant to State Water Resources Control Board (SWRCB) Decision 1631 and Order Nos. 98-05 and 98-07 (Orders), the Los Angeles Department of Water and Power (LADWP) undertakes certain activities in the Mono Basin in compliance with the terms and conditions of its water right licenses 10191 and 10192. In addition to restoration and monitoring activities covered in this report, LADWP also reports on certain required operational activities.

II. Summary of Mono Basin RY 2014-15 Operations

A. Rush Creek

The runoff from Rush Creek was approximately 23,774 AF which amounts to the total water delivered to GLR's 'Damsite'. The highest flow of 132 cfs occurred on June 5, 2014.

Rush Creek flows below 'the Narrows', which consist of Rush Creek releases (Return Ditch, Spill, and 5-Siphons augmentation) combined with Parker and Walker Creek flows, had an approximate total of 33,581 AF. This flow terminated into Mono Lake.

RY 2014 was forecasted as a Dry year type and as such, following Guideline 'A', there was no peak flow released.

1. Rush Creek Augmentation

To meet high flow targets for lower Rush Creek, LADWP at times must employ facilities in addition to the Mono Gate One Return Ditch (MGORD) which has a 380 cfs capacity limit. During wetter years, LADWP utilizes one or both of its additional facilities to release higher peak flows. These facilities include the 5-Siphons bypass, which can release up to 100 cfs from Lee Vining Creek, and the GLR Spillway which can release large reservoir spills into lower Rush Creek during the wetter years.

5-Siphons Bypass
RY 2014 was forecasted as a Dry year type and as such, following Guideline 'A', there was no peak flow released in Rush Creek and therefore 5-Siphons were not utilized.

Grant Reservoir Spill
Grant did not spill during RY 2014.

B. Lee Vining Creek

RY 2014 was forecasted as a Dry year type and as such, following Guideline 'A', there was no 'pass the peak' operation.

Lee Vining Creek had its highest flow on May 27 with 127 cfs. Total runoff for the year was approximately 25,497 AF.

C. Dry Cycle Channel Maintenance Flows

Because RY2014 was the third consecutive dry year, dry cycle channel maintenance flows were not required in accordance with the GLOMP.

D. Parker and Walker Creeks

Parker and Walker were diverted according to Guideline ‘A’. However, they were only diverted a portion of the time due to the lack of enough runoff.

Parker Creek had its highest flow on June 12 at 23 cfs. Total runoff for the year was approximately 4,349 AF.

Walker Creek had its highest flow on May 28 at 14 cfs. Total runoff for the year was approximately 2,297 AF.

E. Grant Lake Reservoir

Grant Lake began the runoff year at approximately 29,273 AF (7,112.3 ft AMSL). The reservoir did not spill during the RY. Final storage volume by the end of the RY of March 31, 2014 was approximately 15,542 AF (7,095.3 ft AMSL).

F. Exports during RY 2014-15

During RY 2014, LADWP exported 15,938 AF from the Mono Basin, which falls below the allowed 16,000 AF under Decision 1631.

G. Mono Lake Elevations during RY 2014-15

In RY 2014, Mono Lake elevations were as shown in the following table. The Lake elevation was at 6,380.67 ft AMSL at the beginning of the runoff year, and ended the runoff year at 6,379.01 ft AMSL, a decrease of 1.66 ft.

RY 2014-15 Mono Lake Elevation Readings

April 1, 2014	6,380.67
May 1, 2014	6,380.59
June 1, 2014	6,380.39
July 1, 2014	6,380.14
August 1, 2014	6,379.89
September 1, 2014	6,379.60
October 1, 2014	6,379.31
November 1, 2014	6,379.06
December 1, 2014	6,378.92
January 1, 2015	6,378.89
February 1, 2015	6,378.95
March 1, 2015	6,379.04
April 1, 2015	6,379.01

III. Proposed Mono Basin Operations Plan RY 2015-16

A. Forecast for RY 2015-16

The Mono Basin's April 1st forecast for Runoff Year (RY) 2015 for April to March period is 30,400 acre-feet (AF), or 25 percent of average using the 1961-2010 long term mean of 122,333 AF (attached). The April runoff forecast changed slightly from the March runoff forecast. This value puts the year type within the 'Dry' category. According to the Grant Lake Operations Management Plan (GLOMP) approved under SWRCB Order 98-05, LADWP will follow Guideline 'A' (attached) for the operating requirements during RY 2015, with certain variations described below.

B. Rush Creek

Base flows will follow Guideline 'A' of 31 cubic feet per second (cfs) from April 1 to September 30, 2015, and 36 cfs from October 1, 2015 to March 31, 2016, or when Grant Lake Reservoir (GLR) storage drops below 11,500 AF, the equivalent of Rush Creek inflow at 'Damsite', whichever is less. There is no peak flow release requirement for Dry year type.

1. Rush Creek Augmentation

In wetter years, LADWP utilizes one or both of its additional facilities to release higher peak flows. These facilities include the 5-Siphons bypass, which can release as tested 100 cfs from Lee Vining Creek, and the GLR Spillway, which can release large reservoir spills into lower Rush Creek during the wetter years.

5-Siphons Bypass
Aside from utilizing the 5-Siphons bypass facility to augment Rush Creek peak flow requirements, LADWP intends to test the physical capability to augment up to 150 cfs from the Lee Vining Conduit through the 5-Siphons bypass facility provided there is adequate runoff. The forecast being Dry, most likely, it will not be possible this runoff year.

Grant Lake Reservoir Spill
GLR is not forecasted to spill during the RY 2015.

C. Lee Vining Creek

Base flows will follow Guideline 'A' of 37 cfs, or flow at Lee Vining Creek 'Above', whichever is less, from April 1 to September 30, 2015, and 25 cfs, or Lee Vining Creek 'Above', whichever is less, from October 1, 2015 to March 31, 2016. All flows in excess of these requirements will be diverted to GLR through the Lee Vining Conduit. There is no peak flow passing requirement for Dry year type.

D. Dry Cycle Channel Maintenance Flows

RY2015 will be the fourth consecutive dry year, therefore dry cycle channel maintenance flows (CMF) should be released in accordance with the GLOMP (for Rush Creek, if Grant Lake Reservoir storage stays above 11,500 AF). However on May 1, 2015 the parties (MLC, CalTrout, CDFW) and the Stream Scientists requested the CMF not be released on Rush Creek or Lee Vining Creek during the runoff year. LADWP will honor the request.

E. Parker and Walker Creeks

If there is enough runoff available, Parker and Walker creek facilities will be operated according to Guideline ‘A’. If the incoming flow is lower than flows in the Guideline, the facilities will be operated as pass through. If the incoming flow is higher, excess flow will be diverted to GLR.

F. Grant Lake Reservoir (GLR)

GLR storage volume was 15,542 AF, corresponding to a surface elevation of 7,095.3 feet above mean sea level (AMSL) at the start of the runoff year. Using the closest available representative historical inflow data (1990 runoff year at 49 percent of normal), and Guideline ‘A’ baseflows, GLR is projected as shown in Scenario A at the end of this section. Forecasted scenarios will be relatively close only if this year’s hydrology turns out to be similar to the hydrology of the selected historical runoff year. Operations are subject to change with variations in actual hydrology during the upcoming runoff year.

G. Planned Exports for RY 2015-16

LADWP plans to export the allowed 4,500 AF this year in accordance with SWRCB Decision 1631. Deliveries will commence April 1 and are expected to be completed by early May to accommodate inspection, maintenance, and repair of the Mono Craters Tunnel. The tunnel has not been inspected or had maintenance performed for approximately 15 years. It is anticipated that the tunnel could be out of service through the summer and potentially through much of the runoff year if maintenance and repairs are extensive.

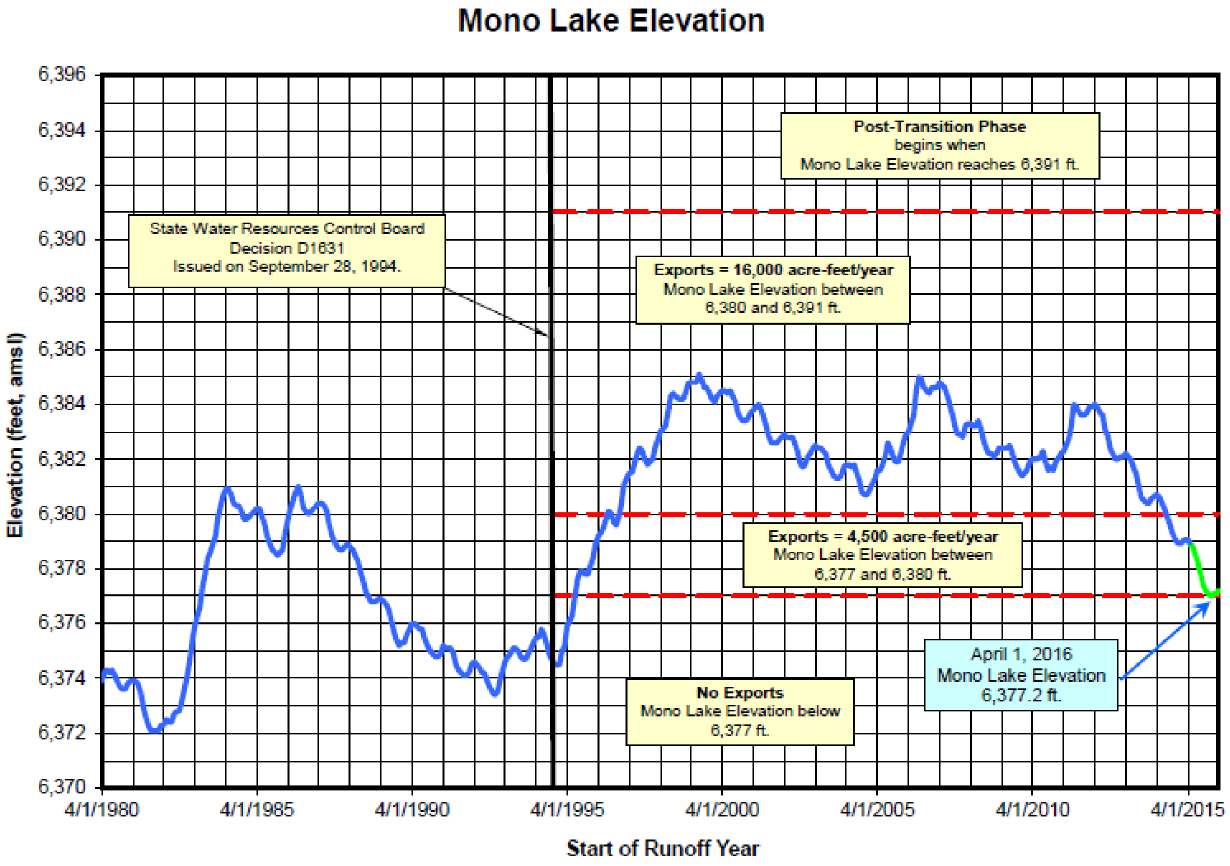
The exports are necessary to provide LADWP operational flexibility and storage in Crowley Reservoir to meet our downstream City water summer demands and other obligations which include irrigation, mitigation projects, and the Lower Owens River Project. The Grant spillway modification project may also require lower elevation for further geotechnical investigation.

H. Expected Mono Lake Elevations during RY 2015-16

Mono Lake began this runoff year at 6,379.01 ft AMSL where it is forecasted to decrease and end the runoff year at approximately 6,377.2 ft AMSL (see attached chart).

ATTACHMENTS

Attachment 1



Attachment 2

2015 EASTERN SIERRA
RUNOFF FORECAST
April 1, 2015

APRIL THROUGH SEPTEMBER RUNOFF

	MOST PROBABLE VALUE (Acre-feet)	MOST PROBABLE VALUE (% of Avg.)	REASONABLE MAXIMUM (% of Avg.)	REASONABLE MINIMUM (% of Avg.)	LONG-TERM MEAN (1961 - 2010) (Acre-feet)
MONO BASIN:	**20,200**	**20%**	32%	7%	103,522
OWENS RIVER BASIN:	**76,000**	**25%**	38%	12%	303,903

APRIL THROUGH MARCH RUNOFF

	MOST PROBABLE VALUE (Acre-feet)	MOST PROBABLE VALUE (% of Avg.)	REASONABLE MAXIMUM (% of Avg.)	REASONABLE MINIMUM (% of Avg.)	LONG-TERM MEAN (1961 - 2010) (Acre-feet)
MONO BASIN:	**30,400**	**25%**	38%	12%	122,333
OWENS RIVER BASIN:	**148,600**	**36%**	49%	24%	412,284

NOTE - Owens River Basin includes Long, Round and Owens Valleys (not incl Laws Area)

MOST PROBABLE - That runoff which is expected if median precipitation occurs after the forecast date.

REASONABLE MAXIMUM - That runoff which is expected to occur if precipitation subsequent to the forecast is equal to the amount which is exceeded on the average once in 10 years.

REASONABLE MINIMUM - That runoff which is expected to occur if precipitation subsequent to the forecast is equal to the amount which is exceeded on the average 9 out of 10 years.

Mono Basin Operations, Guideline 'A'

Year Type……………………………………...……….……….……….……………DRY
Forecasted Runoff in acre-feet...……………….……………...……………….…..………..≤ 83,655

Lower Rush Creek

Base Flows:

	Apr–Sep	Oct-Mar
Flow (cfs)	31	36

Minimum base flows are those specified above unless Grant Lake storage drops below 11,500 acre-feet (7,089.4' elevation), in which case base flows should equal the lesser of Grant Lake inflow or the minimum requirements listed above (D-1631, p 197-198).

Peak Flows: - None.

Ramping: - None.

Lee Vining Creek

Base Flows:

	Apr–Sep	Oct-Mar
Flow (cfs)	37	25

Minimum base flows are those specified above or the stream flow at the point of diversion, whichever is less.

Peak Flows: - None.

Ramping: - None.

Diversions: - Divert flows in excess of base flows.

Augmentation: - None.

Parker and Walker Creeks

Base Flows:

	Apr–Sep	Oct-Mar
Parker (cfs)	9	6
Walker (cfs)	6	4.5

Minimum base flows are those specified above or the stream flow at the point of diversion, whichever is less.

Peak Flows: - None.

Ramping: - None.

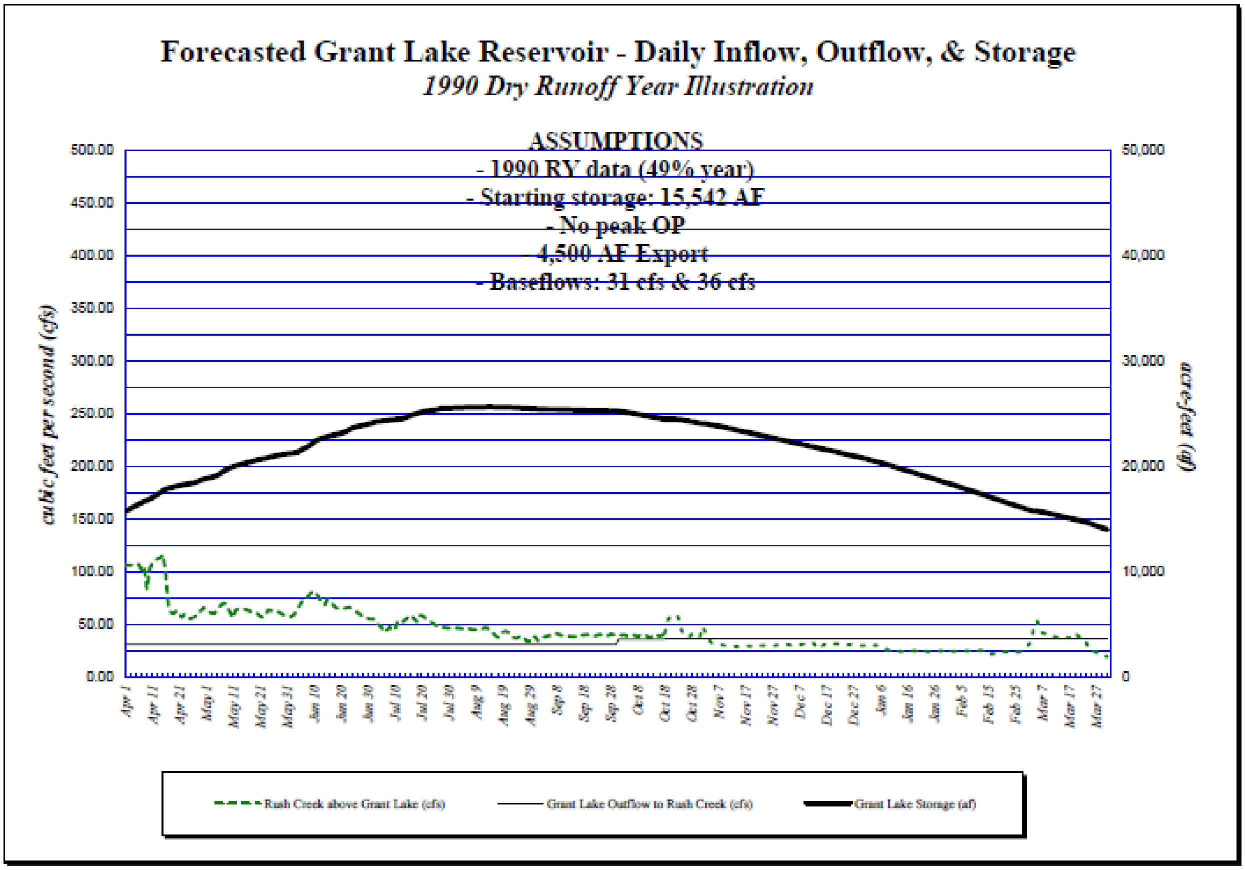
Diversions: - Divert flows in excess of base flows.

Exports

4,500 acre-feet scenario – Maintain 6 cfs export throughout the year.
16,000 acre-feet scenario – As much as possible, maintain 22 cfs export throughout the year.

Attachment 4

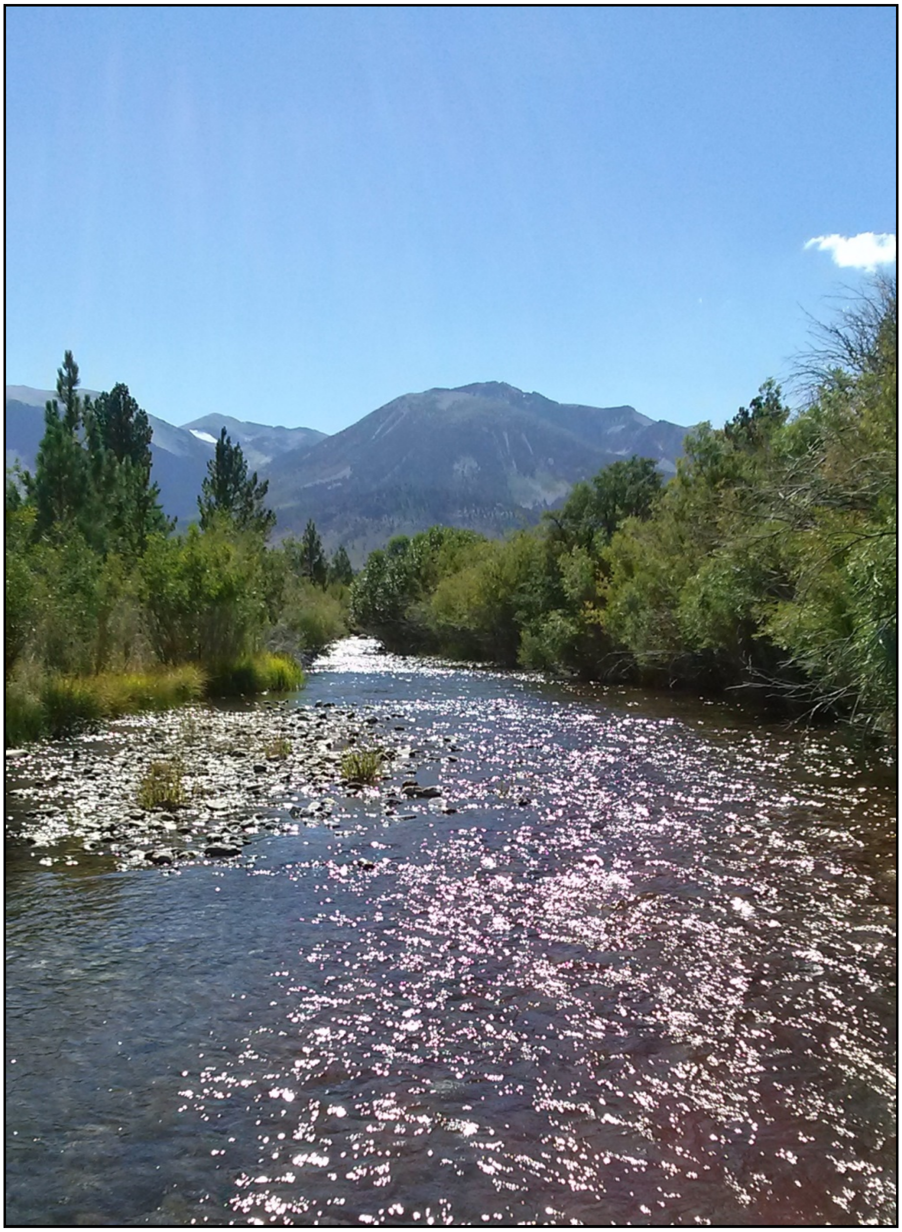
Scenario A: RY 2015/16 Grant Lake Reservoir Storage Projection



Section 3

Fisheries Monitoring Report for Rush, Lee Vining, Parker, and Walker Creeks
2014-15

Mono Basin Fisheries Monitoring Report
Rush, Lee Vining, and Walker Creeks
2014



Prepared by Ross Taylor and Associates for
Los Angeles Department of Water and Power's Annual Compliance Report to the
State Water Resources Control Board

Date: April 15, 2015

Table of Contents

Executive Summary

This report presents results of the eighteenth year of trout population monitoring for Rush, Lee Vining, and Walker Creeks pursuant to State Water Resources Control Board's (SWRCB) Water Right Decision 1631 (D1631) and the sixteenth year following SWRCB Orders #98-05 and #98-07. This report provides the trout population data collected between September 5 and September 16, 2014 as mandated by the Orders and the Settlement Agreement.

The 2014 runoff year (RY) was 48% of normal and classified a dry runoff year type. This was the third consecutive dry runoff year type (RY 2013 was 66% of normal and RY 2012 was 55% of normal). Annual electrofishing mark-recapture monitoring was conducted in three sections of Rush Creek and in the main channel section of Lee Vining Creek. Annual sampling at the County Road section of Rush Creek was discontinued in 2014. Multiple-pass depletion electrofishing was conducted in the Lee Vining Creek side channel and in Walker Creek. These data were used to generate population estimates, density estimates, standing crop estimates, condition factors, relative stock densities, and growth rates from PIT tag recaptures.

Densities of Age-0 Trout

Age-0 brown trout density estimates (numbers per hectare) decreased in the Upper and Bottomlands section of Rush Creek in 2014 when compared to the 2013 values. The Upper Rush section's estimated density of age-0 brown trout decreased by 26% and the Bottomlands section's estimated density of age-0 brown trout decreased by 63%. In Walker Creek, the 2014 density estimate of age-0 brown trout was a 79% decrease from the 2013 estimate and was the fourth lowest in the 16-year sampling period. The 2014 age-0 brown trout density estimate in the main channel of Lee Vining Creek was a 44% decrease from the 2013 estimate. In 2014, no age-0 brown trout were captured in the Lee Vining Creek side channel.

For the sixth consecutive year no age-0 rainbow trout were captured in the Lee Vining Creek side channel. For the Lee Vining Creek main channel, the estimated densities of age-0 rainbow trout decreased by 84% between 2013 and 2014. Between 2012 and 2014, the estimated densities of age-0 rainbow trout decreased by 98%.

Densities of Age-1 and older (aka Age-1+) Trout

From 2013 to 2104, the Upper Rush section's estimated density of age-1+ trout/ha increased by 31% and the Bottomlands section's estimated density of age-1+ trout/ha decreased by 8%. The 2014 density estimate of age-1+ brown trout/ha was the lowest since the start of sampling the Bottomlands section in 2008. The 2014 density estimate of age-1+ brown trout in the Walker Creek section experienced a 7% increase from the 2013 estimate. In the Lee Vining Creek main channel section, the 2014 density estimate of age-1+ brown trout was a 9% decrease from the 2013 estimate. In 2014, the Lee Vining Creek side channel section's density estimate of age-1 and older brown trout/ha was 18% less than the 2013 estimate.

For a fourth consecutive year no age-1 and older rainbow trout were captured in the Lee Vining Creek side channel. Estimated densities of age-1 and older rainbow trout in the Lee Vining Creek main channel decreased by 46% between 2013 and 2014. However, the 2014 estimate was still the fourth highest for the 15 years in which data were collected in this section.

Standing Crop Estimates

The estimated standing crop for brown trout in the Upper Rush section was 167 kg/ha in 2014, a 19% increase from the 2013 estimate. The estimated standing crop for brown trout in the Bottomlands section of Rush Creek was 52 kg/ha in 2014, a 5% decrease from the 2013 estimate.

The estimated standing crop for brown trout in Walker Creek was 189 kg/ha in 2014, a 3% decrease from the 2013 estimate. The 2014 standing crop estimate was the third highest value recorded in Walker Creek over the 16-year sample period.

The Lee Vining Creek main channel in 2014 produced a total estimated standing crop of 140 kg/ha for both rainbow and brown trout and was a 24% decrease from the 2013 estimate. The 2014 brown trout standing crop estimate was 113 kg/ha and the rainbow trout standing crop estimate was 27 kg/ha.

The Lee Vining Creek side channel produced a brown trout standing crop estimate of 30 kg/ha in 2014, a 15% increase compared to the 2013 estimate. No rainbow trout were captured in the side channel in 2014 and none have been sampled in the side channel for four consecutive years (2011-2014).

Condition Factors

Condition factors of brown trout 150 to 250 mm in length in 2014 decreased in three sections (MGORD, LV main channel, and LV side channel) from 2013 and increased in three sections from 2013 (Upper Rush, Bottomlands and Walker). Walker Creek was the only sampling section in 2014 with a condition factor ≥1.00.

The Upper Rush section had a condition factor of 0.99 in 2014, a slight increase from 0.97 in 2013. The Bottomlands section had a condition factor of 0.96 in 2014, an increase from 0.91 in 2013. The 2014 value was the first increase in condition factor after four consecutive decreases in the Bottomlands section since 2009's value of 0.99.

The MGORD's 2014 condition factor was 0.94, unchanged from the 2013 value. The value of 0.94 is still the lowest condition factor for 12 years of sample data for this section (Figure 17). For MGORD brown trout ≥300 mm in length, the 2014 condition factor was 0.95, an increase from 2013's value of 0.90.

For the second consecutive year, brown trout in Lee Vining Creek's main channel had a condition factor below 1.00. The 2014 value was 0.93, down slightly from 2013's value of 0.95. For the past two years, rainbow trout 150 to 250 mm in length from the main channel also had a condition factor of less than 1.00. Rainbow trout in 2014 once again had a better condition factor than the brown trout (0.96 versus 0.95) in the main channel of Lee Vining Creek.

In 2014, brown trout in Lee Vining Creek's side channel had a condition factor 0.89, a decrease from 2013's value of 0.93. This was the third consecutive year in the 15 years of sampling that condition factors were less than 1.00 in the side channel.

In Walker Creek, brown trout had a condition factor of 1.00 in 2014, an increase from 0.93 in 2013.

Relative Stock Densities (RSD)

In the Upper Rush section, the RSD-225 of 10 in 2014 was the lowest value for the 15 years of sampling mainly due to the low numbers of brown trout ≥225 mm (lowest total in past 14 years). The RSD-300 value was 1 in 2014, which has not changed for the past four sampling years.

In the Bottomlands section of Rush Creek, the RSD-225 was 1 in 2014. In 2014, only two brown trout ≥225 mm were captured in the Bottomlands section and one of these was a large PIT-tagged fish that had moved downstream from the MGORD. During the past two sample years, only six fish ≥225 mm have been captured in the Bottomlands section.

In the MGORD the RSD-225 value was 53 in 2014. The RSD-300 value was 7 in 2014, the lowest ever recorded for the 13 years that this section has been sampled. The RSD-375 value in 2014 was 3, the lowest value since 2008. In 2014, only 29 brown trout ≥300 mm were captured during the two electrofishing passes. Of these 29 brown trout, 10 fish were ≥375 mm in length.

RSD values in Lee Vining Creek were generated for the main channel only and for the main channel combined with the side channel. The 2014, RSD-225 values increased compared to 2013, most likely due to the higher numbers of age-2 trout after the high abundance of age-1 brown trout in 2013 that were less than 225 mm in length. For the main channel section of Lee Vining Creek, the 2014 RSD-225 value was 14 and for the main/side channel combined equaled 13.

Introduction

This report presents results of the eighteenth year of trout population monitoring for Rush, Lee Vining, and Walker Creeks pursuant to State Water Resources Control Board's (SWRCB) Water Right Decision 1631 (D1631) and the sixteenth year following SWRCB Orders #98-05 and #98-07.

D1631 states that prior to water diversions on Rush Creek, brown trout averaging thirteen to fourteen inches were regularly observed and that Rush Creek fairly consistently produced brown trout that weighted three-quarters to two pounds. With regards to Lee Vining Creek, it sustained catchable brown trout averaging eight to ten inches in length and some trout reached thirteen to fifteen inches.

A Settlement Agreement signed in 1997 (Settlement Agreement) called for establishment of size and structure of trout populations criteria for determining when stream restoration will be considered complete, i.e. terminated.

Order 98-05 approved the general termination criteria (TC) agreed to in the Settlement Agreement. The general description of the termination criteria described in Order 98-05 included:

1. Whether trout are in good condition. This includes self-sustaining populations of brown trout similar to those that existed prior to the diversion of water by Los Angeles and which can be harvested in moderate numbers.
2. Whether the stream restoration and recovery process has resulted in a functional and self-sustaining stream system with healthy riparian ecosystem components for which no extensive physical manipulation is required on an ongoing basis.

Order 98-05 states that "*the stream restoration program may be terminated upon approval of the State Water Resources Control Board following public notice and opportunity for public comment (SWRCB 1998)*" and the SWRCB will base its determination upon consideration of the two above termination criteria. Order 98-07 also states the monitoring team will develop and implement a means for counting or evaluating the number, weights, lengths and ages of trout present in various reaches of Rush Creek, Lee Vining Creek, Parker Creek and Walker Creek. No specific termination criteria were set forth for Parker and Walker Creeks.

In 2006, the Fisheries Stream Scientist proposed new termination criteria in an attempt to make the calculation and interpretation of the fisheries termination criteria more quantifiable (Hunter 2007). The proposed termination criteria included biomass, density, condition factor, and relative stock density because these are generally accepted by fishery professionals as repeatable and quantifiable measurements of stream-dwelling trout populations. While the termination criteria were proposed, they were never formally adopted by the SWRCB, but have been used by the Stream Scientists in their annual reports. This report provides trout population data collected in 2014 as mandated by the Orders and the Settlement Agreement.

Study Area

Between September 5 and September 16, 2014, Los Angeles Department of Water and Power (LADWP) staff and Ross Taylor, the SWRCB fisheries scientist, conducted the annual fisheries monitoring surveys in six reaches along Rush, Lee Vining, and Walker Creeks in the Mono Lake Basin. The County Road section of Rush Creek was dropped from the sampling regime in 2014. The six reaches were similar in length to those which have been sampled between 2009 and 2013 (Figure 1). Aerial photographs of the 2014 sampling reaches can be found in Appendix A.

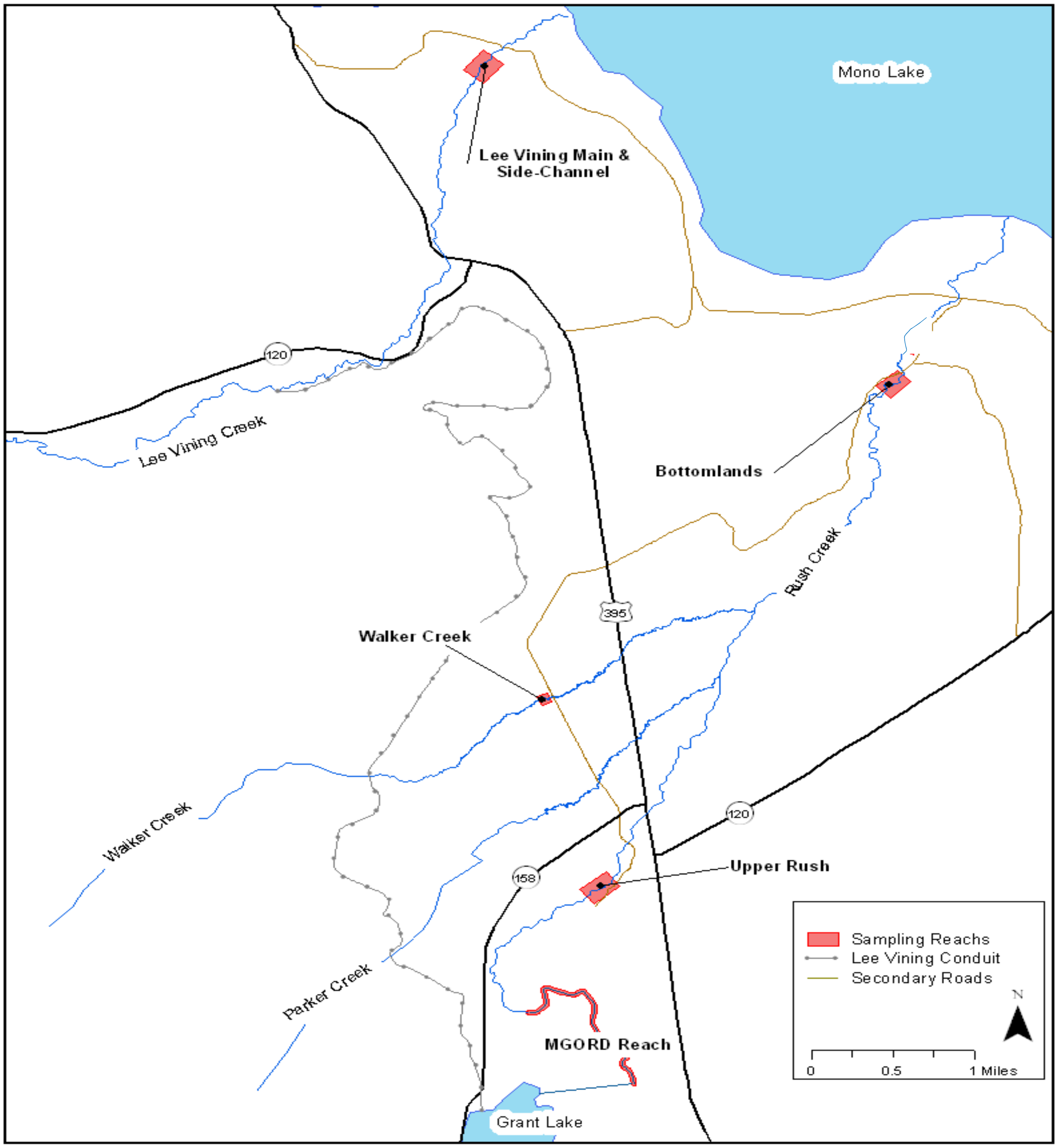


Figure 1. Annual fisheries sampling sites within Mono Basin study area, September 2014.

Hydrology

The 2014 runoff year was 48% of normal and classified a dry runoff year (RY) type. This was the third consecutive dry runoff year type (RY 2013 was 66% of normal and RY 2012 was 55% of normal). Prescribed SRF summer baseflows for Rush and Lee Vining Creeks were 31 and 37 cfs, respectively.

The peak discharges in Rush Creek at Dam Site (located upstream of Grant Lake Reservoir) occurred between May 30th and June 17th, where flows exceeded 100 cfs for 19 days (blue line on Figure 2). Flows released to Rush Creek downstream of Grant Lake Reservoir (GLR) were relatively constant throughout 2014, between 33 and 40 cfs (red line on Figure 2). Accretions from Parker and Walker creeks resulted in minor flow fluctuations and a peak of 58 cfs in Rush Creek below the Narrows on June 6th (green line on Figure 2).

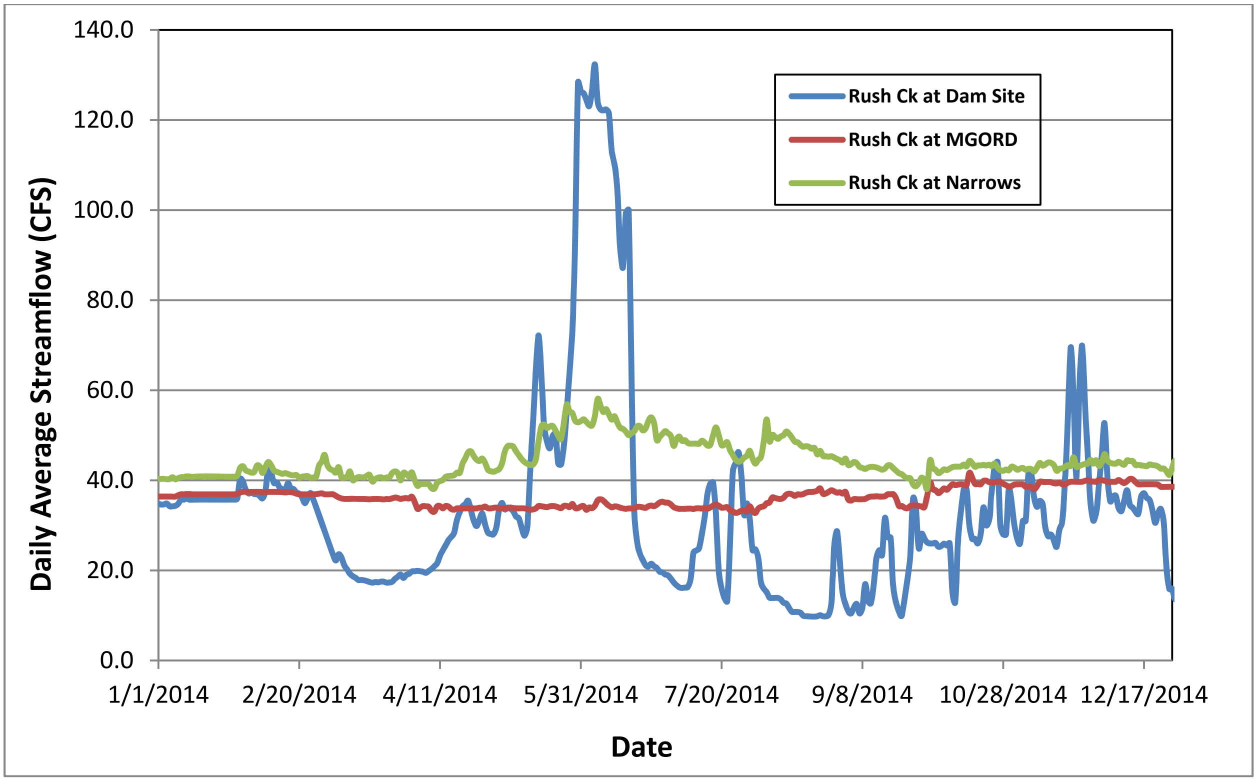


Figure 2. Rush Creek hydrographs between January 1st and December 31st of 2014.

Throughout 2014, flows in Lee Vining Creek below LADWP's intake never exceeded 40 cfs (Figure 3). Starting in late July, some minor flow irregularities occurred due to Southern Cal Edison releasing water upstream to drain reservoirs for dam repair and maintenance (Figure 3).

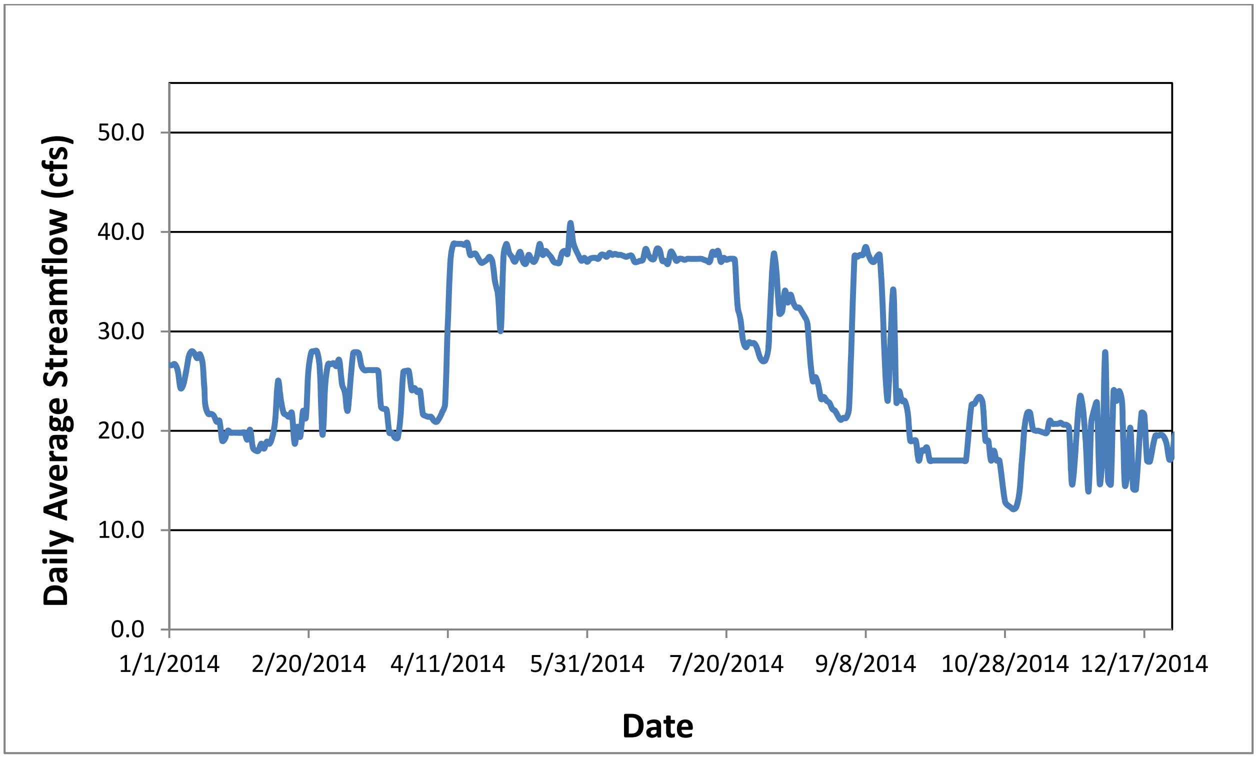


Figure 3. Lee Vining Creek hydrograph below LADWP intake between January 1st and December 31st of 2014.

Grant Lake Reservoir

In 2014, storage elevation levels in Grant Lake Reservoir (GLR) fluctuated from a low of 7,097.8 ft to a high of 7,113.4 ft (Figure 4). GLR's 2014 elevations were lower than 2013's elevations (which were lower than 2012's), most likely due to the three consecutive dry RY's. For the two previous years, prior to snowmelt runoff GLR was at 7,118.8 ft on April 1, 2012 and at 7,114.2 ft on April 25, 2013. Between April 1st and May 25th of 2014, GLR's storage elevation dropped 14.5 feet as LADWP exported a bulk of their allotted 16,000 AF. Maximum GLR elevations have also decreased over the past three years. In 2012, GLR reached a maximum elevation of 7,127.6 ft on May 25th (2.4 ft below the spill elevation of 7,130 ft); in 2013 GLR's maximum elevation was 7,121.8 ft on July 3rd (8.2 ft below spill level and 5.8 ft lower than 2012's maximum level); and in 2014 GLR's maximum elevation was 7,113.4 ft (16.6 feet below spill level and 8.4 feet lower than 2013's maximum level) (Figure 4).

GLR's minimum elevation was 7,097.8 ft on May 25-26, 2014 (Figure 4). Throughout most of the summer of 2014, GLR's elevation was several feet above the "*low*" GLR level as defined in the Synthesis Report by the Stream Scientists as a level where warm water temperatures should be a concern (<20,000 AF storage or approximately 7,100 ft elevation).

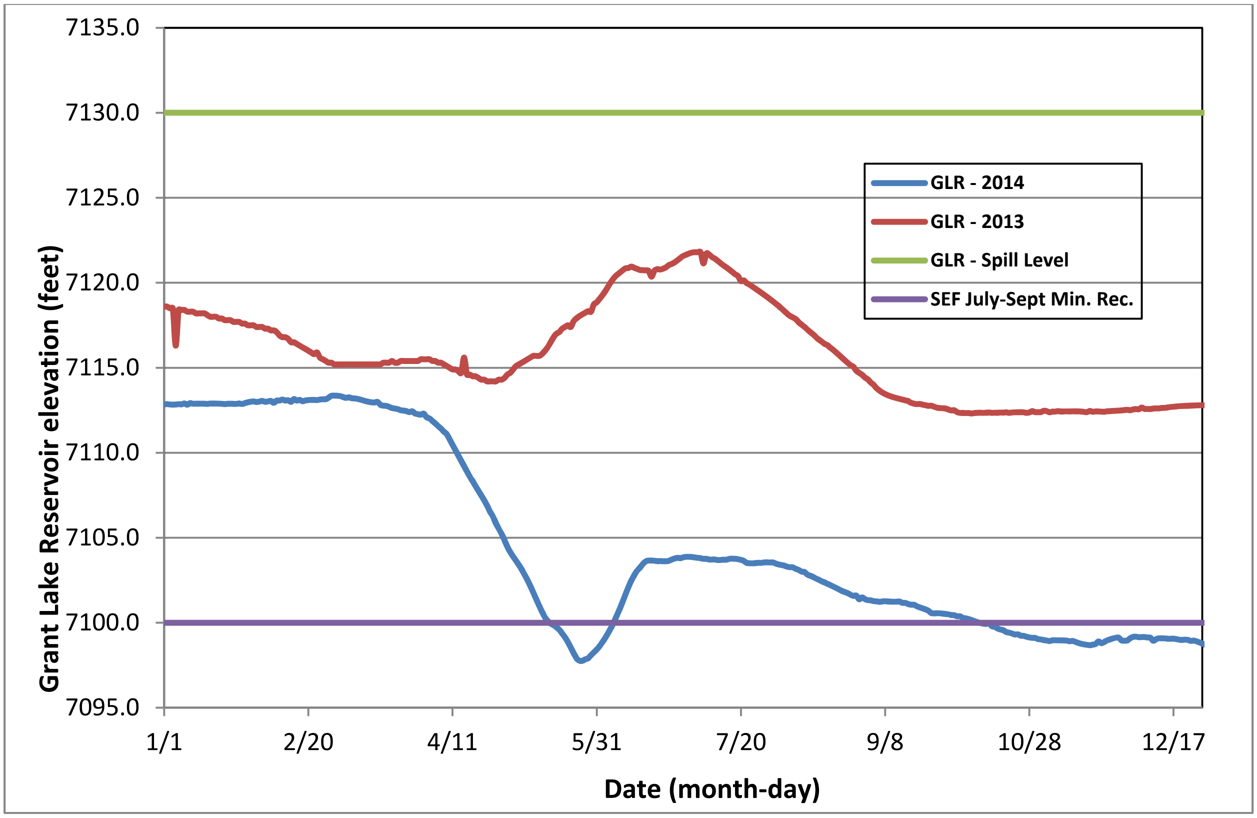


Figure 4. Grant Lake Reservoir's elevation between January 1st and December 31st 2014.

Water Temperature

Although water temperatures were recorded year-round during 2014, summer water temperatures in July-September were more closely examined due to influences of warm temperatures on trout growth and condition factor (Table 1). Daily maximum water temperatures above 70°F were recorded at all Rush Creek temperature monitoring locations below the "Top of MGORD" during the summer of 2014. Rush Creek at "Old Highway 395" had the most days with a daily maximum water temperature exceeding 70°F in 2014 (51 days), followed by "Below Narrows" (46 days), "County Road" (24 days), and "Bottom of MGORD" (20 days)(Table 1). For these four water temperature monitoring locations, the number of days with maximum water temperatures above 70°F in 2014 exceeded the numbers of days documented in 2013 (Table 1). For all five Rush Creek water temperature monitoring locations, the metrics of "daily mean", "average daily minimum" and "average daily maximum" temperatures all increased between the years 2013 and 2014 (Table 1). The Rush Creek "At Dam Site" temperature monitoring site is located upstream of GLR and provides insight to the extent of warming that occurs as water travels through the reservoir (Table 1).

The average daily maximum summer water temperature in Lee Vining Creek was 58.5 °F in 2014 (slight increase from 2013) and warmest temperature recorded all summer long was 63.9°F on July 13th (Table 1). The maximum diurnal fluctuation was 13.0°F and occurred on July 23rd (Table 1).

Table 1. Summary of water temperature data during the summer of RY 2014 (July to September). Averages were calculated for daily mean, daily maximum, and daily minimum temperatures between July 1st and September 30th. All temperature data (Daily Mean, Daily Max, Daily Min, and Max Daily Flux) are in °F. Values for 2013 are provided in ( ) for comparison.

Temperature Monitoring Location	Daily Mean	Ave Daily Minimum	Ave Daily Maximum	No. Days > 70°F	Max Diurnal Fluctuation	Date of Max. Fluct.
Rush Ck. At Dam Site	59.1	57.5	58.5	0	2.5	7/13/14
Rush Ck. – Top of MGORD	64.8 (63.1)	64.6 (62.6)	65.0 (63.7)	0 (0)	3.9 (3.4)	8/13/14
Rush Ck. – Bottom MGORD	64.8 (63.2)	62.9 (60.9)	68.5 (67.1)	20 (1)	8.3 (8.2)	7/13/14
Rush Ck. – Old Highway 395	64.0 (62.6)	60.5 (58.8)	69.8 (68.7)	51 (40)	13.3 (13.5)	7/13/14
Rush Ck. – below Narrows	63.2 (61.2)	57.1 (56.2)	69.4 (67.6)	46 (24)	17.3 (16.3)	7/26/14
Rush Ck. – County Road	62.0 (61.4)	56.7 (56.5)	67.8 (66.6)	24 (7)	17.6 (14.1)	7/26/14
Lee Vining – at intake	53.8 (52.1)	49.9 (46.9)	58.5 (58.0)	0 (0)	13.0 (14.2)	7/23/14
Lee Vining – at County Road	54.9	51.4	59.6	0	11.6	7/01/14

Methods

The annual fisheries monitoring was conducted between September 5 and 16, 2014. Closed population mark-recapture and depletion methods were utilized to estimate trout abundance. The mark-recapture method was used on the Upper, Bottomlands and MGORD sections of Rush Creek and the Lee Vining Creek main channel section. The depletion method was used on the Lee Vining Creek side channel and Walker Creek sections.

For the mark-recapture method to meet the assumption of a closed population, semi-permanent block fences were installed at the upper and lower ends of each section. The semi-permanent fences were 48 inches tall, constructed with ½ inch-mesh hardware cloth, t-posts, and rope. Hardware cloth was stretched across the entire width of the creek and t-posts were then driven at roughly five-foot intervals through the cloth on the upstream side approximately one foot from the edge. Rocks were placed on the lower edge to prevent trout from swimming underneath the fence. Rope was secured across the tops of the t-posts and tied to both banks upstream of the fence. The hardware cloth downstream of the t-posts was raised and secured to the rope with bailing wire. Fences were raised the morning of the mark run and left in place for seven days until the recapture run was finished. To prevent failure, all fences were cleaned of leaves, twigs, and checked for mortalities twice daily (morning and evening).

Depletion estimates only required temporary fencing to prevent fish movement in and out of the study area while conducting the survey. Temporary fencing was erected at the upper and lower ends of the study areas with 3/16 inch-mesh nylon seine nets installed across the channel. Rocks were placed on the lead line to prevent trout from swimming underneath the seine net. Sticks were used to keep the top of the seine above the water line. Both ends of the seine net were then tied to bank vegetation to hold it in place.

Equipment used to conduct mark-recapture electrofishing on Rush Creek included a six foot plastic barge that contained the Smith-Root© 2.5 GPP electro-fishing system, an insulated cooler, and battery powered aerators. The Smith-Root© 2.5 GPP electro-fishing system included a 5.5 horsepower Honda© generator which powered the 2.5 GPP control box. Electricity from the 2.5 GPP control box was introduced into the water via two anodes. The electrical circuit was completed by the metal plate cathode attached to the bottom of the barge. Due to the steep-gradient and relatively narrow width of Lee Vining Creek, two Smith-Root© LR-24 backpack electrofisher units were used for the mark-recapture runs.

Mark-recapture runs on Rush Creek consisted of a single downstream pass starting at the upper block fence and ending at the lower block fence. In 2014, the field crew consisted of a barge operator, two anode operators, and four netters, two for each anode. The barge operator’s job consisted of carefully maneuvering the barge down the creek, and ensuring overall safety of the entire crew. The anode operator’s job was to safely shock and hold trout until they were netted. The netters’ job was to net and transport fish to the insulated cooler and monitor trout for signs of stress. Once the cooler was full, electrofishing was temporarily stopped to process the trout. The trout were then transferred from the cooler to live cars and placed back in the creek. The trout were then processed in small batches and then returned to a recovery live car in the creek. Once all the trout were processed at a sub-stop, the crew resumed electrofishing until the cooler was once again full.

Mark-recapture runs on Lee Vining Creek consisted of an upstream pass starting at the lower block fence and ending at the upper block fence followed shortly by a downstream pass back to the lower block fence. The electrofishing crew consisted of two crew members running the backpack electrofishers, three netters, and one bucket carrier who transported the captured trout to several live cars positioned throughout the sample reach. Once the up-and-down passes were finished, the crew processed the trout.

Due to the depth of the MGORD, all electrofishing and netting was done from inside a drift boat. The drift boat was held perpendicular to the flow by two crew members who walked it down the channel. The electrofishing barge was tied off to the upstream side of the drift boat and a single throw anode was used. A single netter used a long handled dipnet to net the stunned trout, which were then placed in an insulated cooler equipped with aerators. A safety officer sat at the stern of the drift boat whose job was to monitor the trout in the cooler, the electrofishing equipment, the electrofishing crew and shut off the power should the need arise. Once the cooler was full, the trout were moved to a live car and placed back in the creek for the shore crew to process before continuing the electrofishing effort.

The Walker Creek and Lee Vining Creek side channel (B-1 side channel) depletions were both two-pass depletions. A single pass was considered an upstream pass from the lower seine net to the upper seine net followed by a downstream pass back to the lower seine net. One member of the electrofishing crew operated the LR-24 electrofisher; another member was the primary netter and a third member was the backup netter/bucket carrier. The other crew members processed the trout captured during the first pass while the electrofishing crew was conducting on the second pass. Processed first-pass fish were temporarily held in a live car until the second pass was completed and it was determined that only two passes were required to generate a suitable estimate. Once the electrofishing crew was finished with the second pass, those trout were then processed.

To process trout during the mark-run, small batches of fish from the live car were transferred to a five gallon bucket equipped with aerators. Trout were then anesthetized, identified as either brown trout or rainbow trout, measured to the nearest millimeter (total length), and weighed to the nearest gram on an electronic balance. Trout were then “marked” with a small (< 3 mm) fin clip for identification during the recapture run. Trout captured in the Rush Creek MGORD and Bottomlands sections and the main channel of Lee Vining Creek received anal fin clips. Trout captured in the Upper section of Rush Creek received a lower caudal clip. Before placing trout into the aerated recovery bucket, each fish was examined for a missing adipose fin. Trout missing their adipose fin were then scanned for their Passive Integrated Transponder (PIT) tag number. Any trout missing their adipose fin that failed to produce a tag number when scanned were recorded as having “shed” the PIT tag. Partially regenerated adipose fins of fish with PIT tags were reclipped for ease of future identification. Once recovered, fish were then moved from the recovery bucket to a live car to be held until the day’s sampling effort was completed; this was done to prevent captured fish from potentially moving downstream into the actively sampled section. At the end of the electrofishing effort, fish were released from the live cars back into the sub-sections they had been captured in. Fish were then provided a seven-day period to remix back into the section's population prior to conducting the recapture-run.

Processing trout during the recapture-run was similar to the mark-run. Trout were transferred in small batches to a five gallon bucket. They were then anesthetized, identified, and examined for the "mark" fin clip. Trout that were fin clipped were only measured to the nearest millimeter and placed in the recovery bucket. Trout that were not clipped during the "mark" run (i.e. new fish) were measured to the nearest millimeter "total length," weighed to the nearest gram, and examined for missing adipose fins. Trout missing adipose fins were then scanned for their PIT tag number then placed into recovery. Again, trout that failed to produce a tag number were recorded as having "shed" the PIT tag.

Between 2009 and 2012, PIT tags were implanted in most age-0 trout in Rush and Lee Vining Creeks and in all ages of trout in the MGORD. No PIT tags were deployed in 2013; however the tagging program was resumed during the 2104 field season.

All data collected in the field, were written on data sheets and entered into Excel spreadsheets using a field laptop computer. Data sheets were then used to proof the Excel spreadsheets back at the office.

Calculations

To calculate the area of each sample section, channel lengths and wetted widths were measured within the sample reaches. Wetted widths were measured at 10-meter intervals to 0.1 meter accuracy within each reach. Average wetted widths were used in area calculations which were then used to calculate each section's estimates of trout biomass and density.

Mark-recapture population estimates were derived from the Chapman modification of the Petersen equation (Ricker 1975 as cited in Taylor and Knudson 2011). Depletion estimates and condition factors were derived from MicroFish 3.0 software program. Estimates were generated for three size groups of trout: <125 mm in length, 125-199 mm in length, and ≥200 mm in length (200 mm is approximately eight inches).

Mortalities

For the purpose of conducting the mark-recapture methodology, accounting for fish killed during the sampling process was important. Depending on when the fish were killed and whether or not they were sampled during the mark-run, how these fish were accounted for varied.

All fish killed during the mark-run were unavailable for sampling during the recapture-run. These fish were considered "morts" in the mark-run for the purposes of mark-recapture estimates, were removed from the mark-run data, and then were added back into the total estimate after computing the mark-recapture estimate.

During the seven-day period between the mark-run and the recapture-run, when the block fences were cleaned twice daily, fence cleaners also looked for additional morts. When "marked" morts were found on the fences, we went back into the mark-run data and assigned block fence morts on a one-to-one basis as "morts" to individual fish on the mark-run based on species and size. When this occurred, a comment was added to the individual fish, such as "assigned as fence mort". These marked morts were then removed from the mark-run data since they were unavailable for sampling during the recapture-run. Because of fin deterioration on some morts, exact lengths were not always available. Fortunately, it was not critical to match the exact length when assigning these marked fence morts to fish from the mark-run, but it was important that the fence morts were placed within the proper "length group" for which estimates were computed. As with fish killed during the mark-run, these marked fence morts were added back into the total estimate after the mark-recapture estimate was computed.

Unmarked fence morts (fish not caught and clipped during the mark-run) were measured and tallied by the three length groups for which estimates were computed. These fish were then added to the total number of morts (for each length group), which were then added back into the mark-recapture estimates to provide unbiased total estimates for each length group.

Length-Weight Relationships

Length-weight regressions (Cone 1989 as cited in Taylor and Knudson. 2011) were calculated for all brown trout greater than 100 mm in all sections of Rush Creek. Regressions using Log10 transformed data were used to compare length-weight relationships by year and by section.

Fulton-type condition factors were computed in MicroFish 3.0 using methods previously reported (Taylor and Knudson 2011) for brown trout 150 to 250 mm. A trout condition factor of 1.00 was considered average (Reimers 1963; Blackwell et al. 2000).

Relative Stock Density (RSD) Calculations

Relative stock density (RSD) is a numerical descriptor of length frequency data (Hunter et al. 2007). RSD values are the proportions (percentage x 100) of the total number of brown trout ≥150 mm in length that are also ≥225 mm or (RSD-225), ≥300 mm (RSD-300) and ≥375 mm or (RSD-375). These three RSD values are calculated by the following equations:

RSD-225 = [(# of brown trout ≥225 mm) ÷ (# of brown trout ≥150 mm)] x 100
RSD-300 = [(# of brown trout ≥300 mm) ÷ (# of brown trout ≥150 mm)] x 100
RSD-375 = [(# of brown trout ≥375 mm) ÷ (# of brown trout ≥150 mm)] x 100

Termination Criteria Calculations and Analyses

Information regarding the proposed termination criteria, calculations, and analyses was conducted as described in past Annual Fisheries Reports (Taylor and Knudson 2011).

Results

Channel Lengths and Widths

Differences in wetted widths between years can be due to several factors such as, magnitude of spring peak flows, stream flows at time of measurements, and locations of where measurements were taken. In 2014, widths in Rush Creek and Lee Vining were slightly narrower than in 2013; whereas in Walker Creek the 2014 width was slightly wider than the 2013 measurement. Lengths, widths, and areas from 2013 are provided for comparisons (Table 2).

Table 2. Total length, average wetted width, and total surface area of sample sections in Rush, Lee Vining, and Walker Creeks sampled between September 5-16, 2014. Values from 2013 are provided for comparisons.

Sample Section	Length (m) 2013	Width (m) 2013	Area (m^2) 2013	Length (m) 2014	Width (m) 2014	Area (m^2) 2014	Area (ha) 2014
Rush – Upper	430	8.3	3,569.0	430	7.2	3,096.0	0.3096
Rush - Bottomlands	437	7.5	3,277.5	437	7.0	3,059.0	0.3059
Rush – MGORD	2,230	N/A	N/A	2,230	8.3	18,509.0	1.8509
Lee Vining – Main	255	5.7	1,453.5	255	5.5	1,402.5	0.14025
Lee Vining - Side	122	1.6	195.2	127	1.5	190.5	0.01905
Walker Creek	193	1.7	328.1	193	1.9	366.7	0.03667

Trout Population Abundance

Rush Creek

In 2014, a total of 1,056 brown trout ranging in size from 59 mm to 370 mm were captured in Upper Rush section (Figure 5). Age-0 brown trout comprised 62% of the total catch this year (compared to 69% in 2013). Upper Rush supported an estimated 1,309 age-0 brown trout in 2014 (including morts) compared to 2,046 age brown trout in 2013 (a 36% decrease between 2013 and 2014). Between 2012 and 2014, the estimate of age-0 brown trout in Upper Rush has decreased from 2,895 to 1,309 fish (a 55% decrease). Standard error for the 2014 age-0 brown trout estimate was 7% of the estimate, the same value as in 2013 (Table 3).

In 2014, brown trout 125-199 mm in length comprised 31% of the total catch in the Upper Rush section (compared to 24% in 2013). This section supported an estimated 553 brown trout 125-199 mm in length in 2014 (including morts) compared to 444 fish in 2013 (a 25% increase). Standard error for this size class was 8% of the estimate (was 7% for the 2013 estimate).

Brown trout ≥200 mm in length comprised of 7% of the Upper Rush total catch in 2014 (compared to 8% in 2013). In 2014, Upper Rush supported an estimated 105 brown trout ≥200 mm in length compared to an estimate of 135 fish in 2013 (a 22% decrease). Between 2012 and 2014, the estimate of brown trout ≥200 mm in Upper Rush has decreased from 177 to 105 fish (a 41% decrease). Standard error for this size class was 11% of the 2014 estimate versus 9% in 2013. In 2014, four brown trout greater than 300 mm in length were captured in the Upper Rush section; these fish were 305, 348, 358, and 370 mm in length (Figure 5).

A total of 10 rainbow trout were captured on the Upper Rush section comprising 0.9% of the total catch in 2014 (Table 3). The 10 rainbow trout ranged in size from 71 mm to 262 mm (Figure 6). Two of the captured rainbow trout were age-0 fish, six fish were in the 125-199 mm size class, and the remaining two fish were ≥200 mm in length. In 2014, there were too few recaptures of rainbow trout to generate estimates for any of the size classes (Table 3).

Within the Bottomlands section of Rush Creek a total of 330 brown trout were captured in 2014 (Table 3) which ranged in size from 65 mm to 440 mm (Figure 7). Age-0 brown trout comprised 31% of the total catch in 2014 versus 50% of the total catch in 2013. The Bottomlands section supported an estimated 174 age-0 brown trout in 2014 versus 508 age-0 fish in 2013 (a 66% decrease). Between 2012 and 2014, the estimate of age-0 brown trout in the Bottomlands section has decreased from 843 fish to 107 fish (a 79% decrease). Standard error on age-0 brown trout was 14% of the estimate in 2014 compared to 13% in 2013 (Table 3).

Brown trout 125-199 mm in length comprised 61% of the total catch in the Bottomlands section in 2014 versus 46% of the total catch in 2013. This section supported an estimated 276 brown trout 125-199 mm in length in 2014 compared to 331 fish in 2013 (a 17% decrease). Between 2012 and 2014, the estimate of 125-199 mm brown trout in the Bottomlands section decreased from 460 to 276 fish (a 40% decrease). Standard error for this size class was 7% of the estimate in 2014 versus 8% in 2013 (Table 3).

Brown trout ≥200 mm in length comprised of 8% of the total catch in 2014 (4% in 2013) with the largest trout 440 mm in length. This large trout was a PIT tagged fish that had last been captured in the MGORD during the 2013 sampling. The Bottomlands supported an estimated 30 brown trout ≥200 mm in 2014 compared to 26 trout in 2013 (a 15% increase). Standard error for this size class was 10% of the 2014 estimate versus 15% in 2013 (Table 3).

In 2014, four rainbow trout were captured in the Bottomlands section of Rush Creek (Figure 8). These four rainbow trout were 60, 162, 168 and 178 mm in length. No estimates of rainbow trout were possible due to insufficient numbers (Table 3).

Table 3. Rush Creek and Lee Vining Creek mark-recapture estimates for 2014 showing total number of trout marked (M), total number captured on the recapture run (C), total number recaptured on the recapture run (R), and total estimated number and its associated standard error (S.E.) by stream, section, date, species, and size class. Mortalities (Morts) were those trout that were captured during the mark run, but died prior to the recapture run. Mortalities were not included in mark-recapture estimates and were added to estimates for accurate total estimates. NP = estimate not possible.

Stream		Mark - recapture estimate					
Section Species Date	Size Class (mm)	M	C	R	Morts	**Estimate**	S.E.
Rush Creek							
Upper Rush-BNT							
9/05/2014 & 9/12/2014							
	0 - 124 mm	377	378	109	8	**1301**	88
	125 - 199 mm	200	194	70	2	**551**	42
	>200 mm	38	59	21	0	**105**	12
Upper Rush-RBT							
9/05/2014 & 9/12/2014							
	0 - 124 mm	0	2	0	0	**NP**	NP
	125 - 199 mm	5	1	0	0	**NP**	NP
	>200 mm	2	0	0	0	**NP**	NP
Bottomlands-BNT							
9/06/2014 & 9/13/2014							
	0 - 124 mm	59	63	21	0	**174**	24
	125 - 199 mm	146	116	61	0	**276**	18
	>200 mm	25	19	16	0	**30**	3
Bottomlands-RBT							
9/06/2014 & 9/13/2014							
	0 - 124 mm	1	0	0	0	**NP**	NP
	125 - 199 mm	3	1	1	0	**NP**	NP
	>200 mm	0	0	0	0	**NP**	NP
MGORD-BNT							
9/08/2014 & 9/15/2014							
	0 - 124 mm	7	13	0	1	**NP**	NP
	125 - 199 mm	42	60	10	1	**237**	54
	>200 mm	155	195	54	0	**555**	51

Stream Section Species Date		Mark - recapture estimate					
	Size Class (mm)	M	C	R	Morts	**Estimate**	S.E.
Lee Vining Creek							
Main Channel-BNT							
9/09/2014 & 9/16/2014							
	0 - 124 mm	81	76	25	0	**242**	31
	125 - 199 mm	117	133	56	2	**276**	20
	>200 mm	21	23	14	0	**34**	9
Main Channel-RBT							
9/09/2014 & 9/16/2014							
	0 - 124 mm	4	4	2	0	**NP**	NP
	125 - 199 mm	24	24	12	0	**47**	6
	>200 mm	12	12	9	0	**16**	1

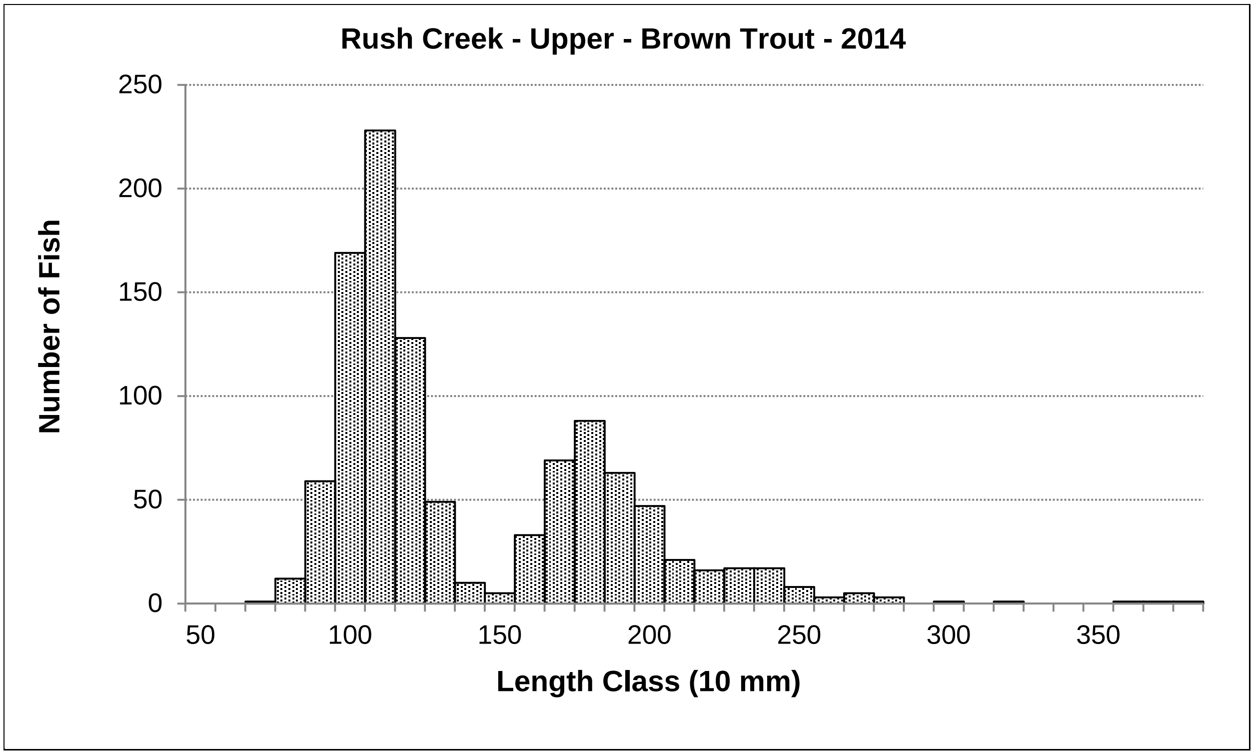


Figure 5. Length-frequency histogram for Upper Rush captured brown trout, September 5th and 12th, 2014.

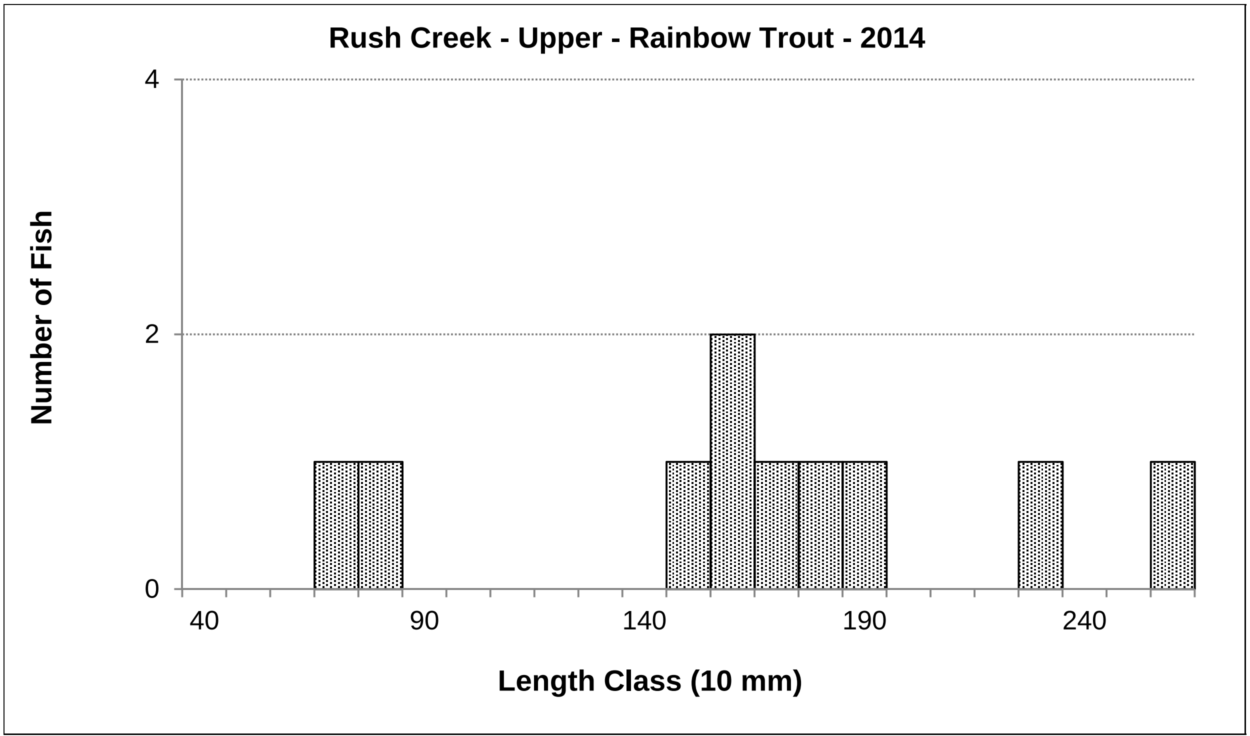


Figure 6. Length-frequency histogram for Upper Rush captured rainbow trout, September 5th and 12th, 2014.

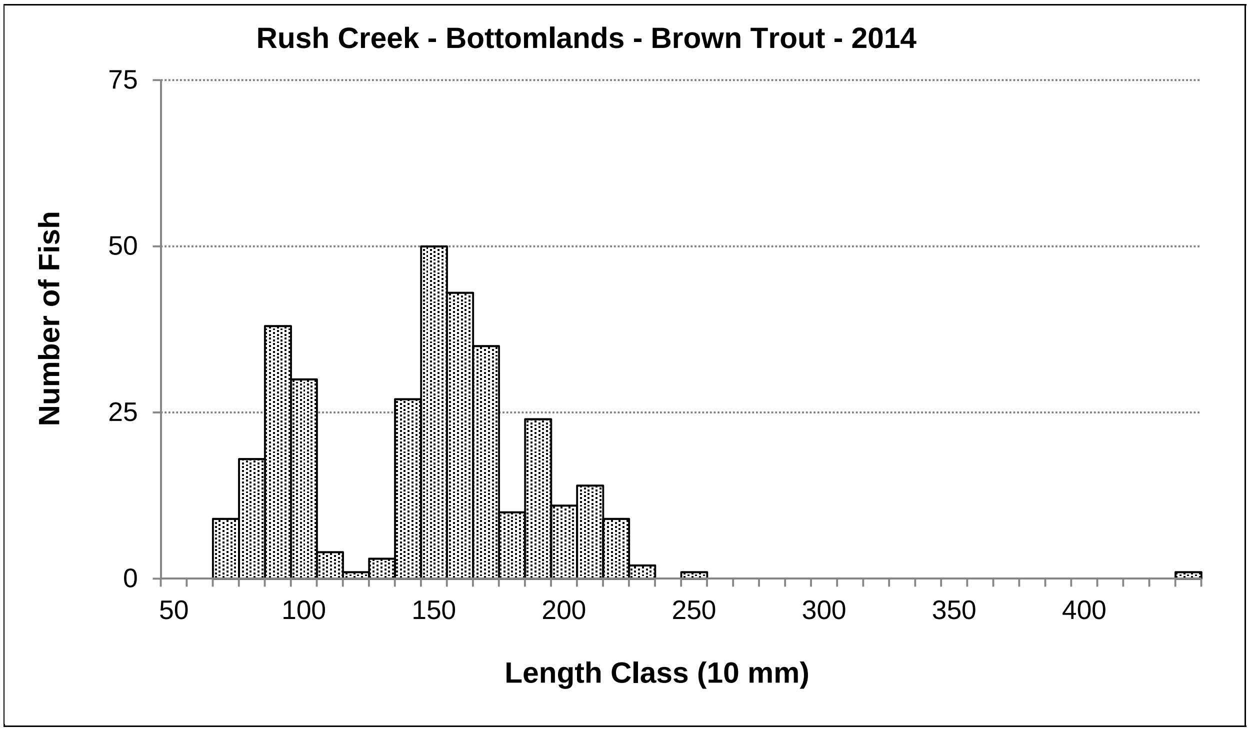


Figure 7. Length-frequency histogram of captured brown trout in the Bottomlands section of Rush Creek, September 6th and 13th, 2014.

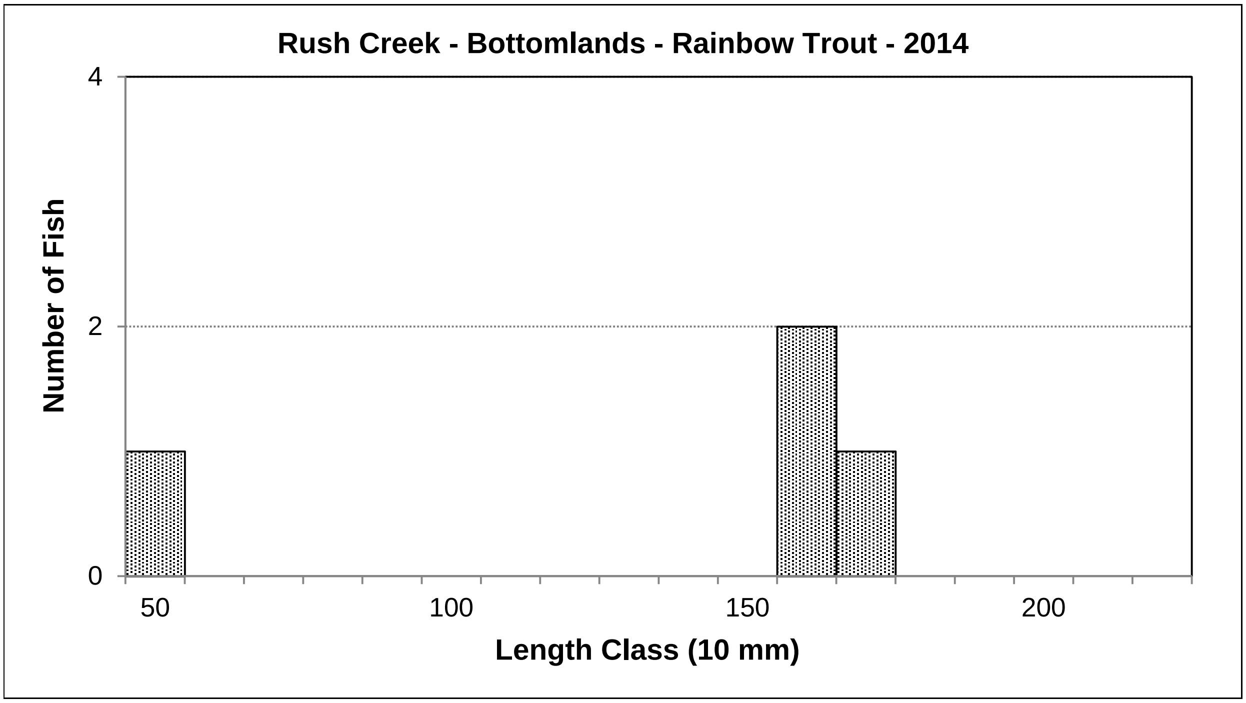


Figure 8. Length-frequency histogram of captured rainbow trout in the Bottomlands section of Rush Creek, September 6th and 13th, 2014.

Within the MGORD section of Rush Creek a total of 410 brown trout were captured in 2014 and these fish ranged in size from 83 mm to 570 mm (Table 3 and Figure 9). Age-0 brown trout comprised 5% of the total number of fish captured in 2014. No estimate of age-0 brown trout within the MGORD section was possible due to insufficient numbers of recaptures (Table 3).

In 2014, brown trout in 125-199 mm size class comprised 23% of the total catch in the MGORD section (Table 3). This section supported an estimated 238 brown trout in the 125-199 mm size class in 2014 (Table 3) compared to 194 trout in 2012 (a 23% increase). Standard error for this size class was 23% of the estimate in 2014 compared to 18% in 2012.

Brown trout ≥200 mm in length comprised of 72% of the total catch in 2014 with the largest trout 570 mm in length. In 2014, 29 brown trout ≥300 mm were captured in the MGORD (7 % of the total catch). The MGORD section supported an estimated 555 brown trout ≥200 mm in 2014 (Table 3) versus 873 fish in 2012 (a 36% decrease). Standard error for this size class was 9% of the estimate in 2014 (versus 4% in 2012).

In 2014, no rainbow trout were captured on the MGORD. In previous years, nine rainbow trout were captured in 2013 and 40 rainbow trout were captured in 2012.

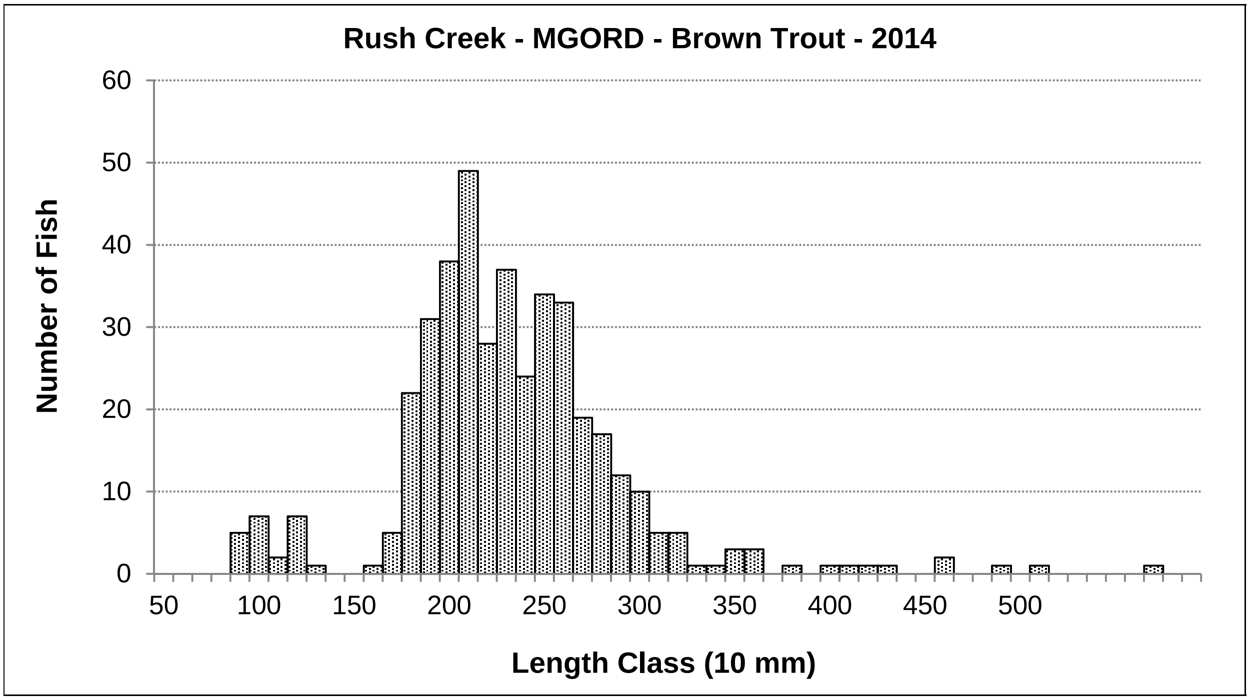


Figure 9. Length-frequency histogram of captured brown trout in the MGORD section of Rush Creek, September 8th and 15th, 2014.

Lee Vining Creek

In 2014, a total of 414 trout were captured in the Lee Vining Creek main channel section (versus 658 fish in 2013 and 838 fish in 2012) (Table 3). Of the 414 trout captured in 2014, 357 were brown trout making up 86% of the total trout captured. Brown trout ranged in size from 69 mm to 254 mm (Figure 10). Age-0 fish comprised 37% of the total brown trout catch in 2014 (compared to 45% in 2013). Lee Vining Creek's main channel section supported an estimated 242 age-0 brown trout in 2014, compared to an estimated 444 age-0 brown trout in 2013 (a 45% decrease). Between 2012 and 2014, the age-0 brown trout estimates dropped from 677 fish to 242 fish (a 64% decrease). Standard error for age-0 brown trout was 13% of the 2014 estimate vs. 2013's 10% (Table 3).

In 2014, 195 brown trout 125-199 mm in length were captured and comprised 55% of the total brown trout catch in Lee Vining Creek's main channel section (versus 51% in 2013). This section supported an estimated 276 brown trout 125-199 mm in length in 2014 compared to 331 brown trout in 2013 (a 17% decrease). Standard error for this size class in 2014 was 7% of the estimate compared to 8% in 2013.

Brown trout ≥200 mm in length comprised of 8% of the total brown trout catch in 2014. Lee Vining Creek's main channel supported an estimated 34 brown ≥200 mm (versus 25 fish in 2013) (Table 3). Standard error for this size class was 26% of the 2014 estimate vs. 7% in 2013.

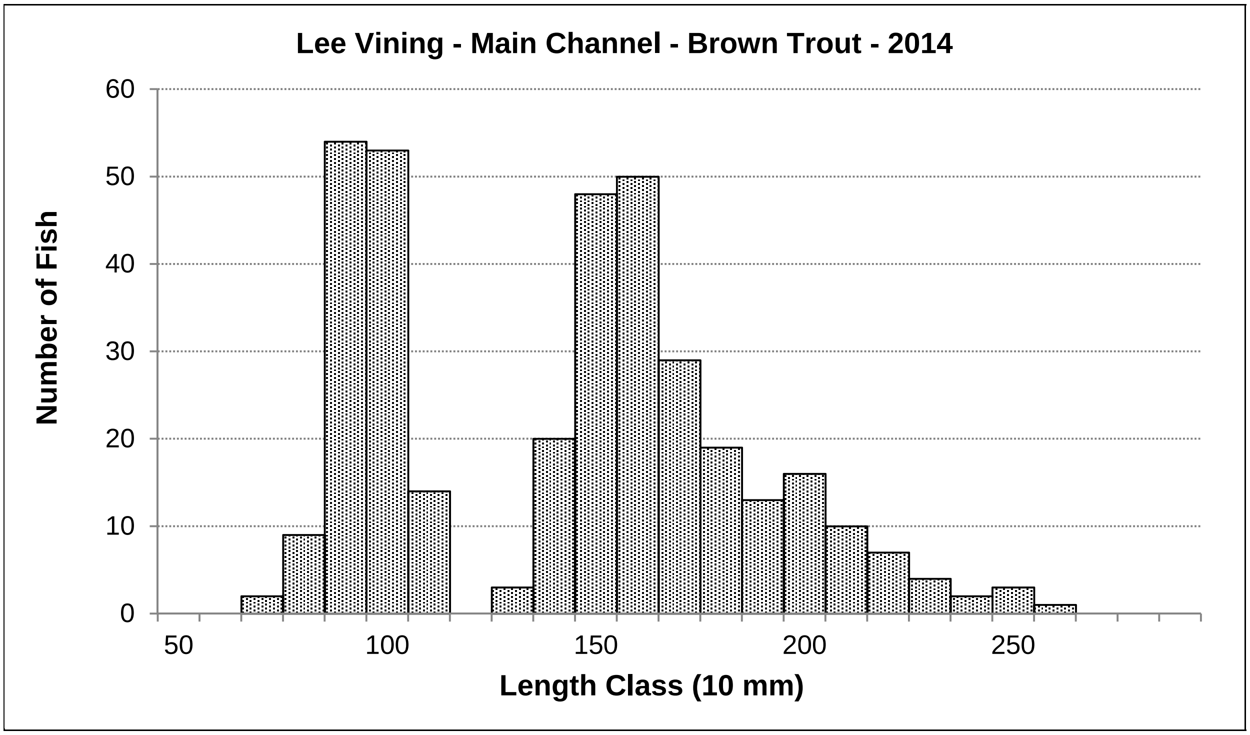


Figure 10. Length-frequency histogram of captured brown trout in the main channel section of Lee Vining Creek, September 9th and 16th, 2014.

A total of 57 rainbow trout were captured in Lee Vining's main channel making up approximately 14% of the total catch in 2014 (versus 19% of the 2013 total catch) (Table 3). Rainbow trout ranged in size from 69 mm to 265 mm (Figure 11). Of the 57 rainbow trout captured, six fish were in the age-0 size class. No valid age-0 estimate of rainbow trout was possible for 2014 due to insufficient numbers of fish caught (Table 3).

The 36 rainbow trout captured in the 125-199 mm size class comprised 63% of the total rainbow trout catch in 2014. The 2014 estimate for rainbow trout in this size class was 47 fish versus an estimate of 94 fish in 2013 (a 50% decrease). In 2014, the standard error was 13% of the estimate compared to a standard error 8% of the estimate in 2013 (Table 3).

The 15 rainbow trout caught in Lee Vining Creek's main channel ≥200 mm in length comprised 26% of the total rainbow trout catch in 2014. The 2014 estimate for rainbow trout in this size class was 16 fish versus an estimate of 26 fish in 2013 (a 38% decrease). In 2014, the standard error was 6% of the estimate compared to a standard error was 8% of the estimate in 2013 (Table 3).

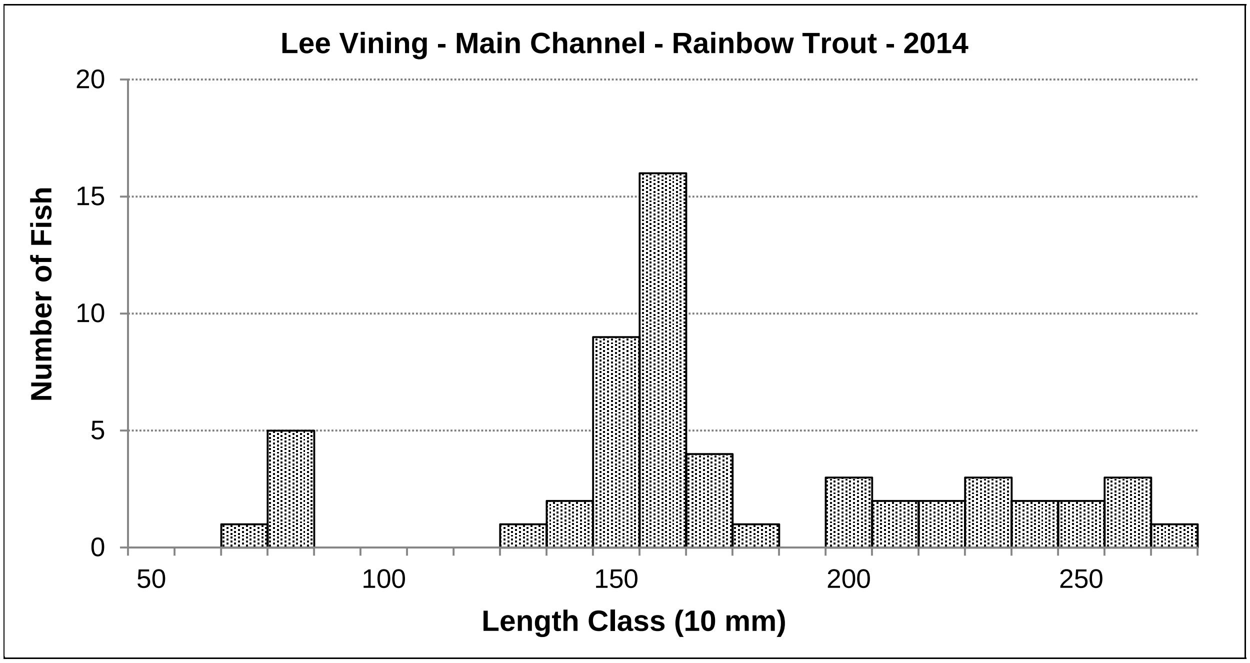


Figure 11. Length-frequency histogram of captured rainbow trout in the main channel section of Lee Vining Creek, September 9th and 16th, 2014.

In the Lee Vining Creek side channel, 12 brown trout were captured in two electrofishing passes during the 2014 sampling (Table 4). No age-0 fish were captured and all 12 fish were caught on the first pass (Figure 12). Brown trout 125-199 mm in length made up 92% of the total catch in 2014. The estimate for this size class was 11 brown trout (Table 4). Only one brown trout in the ≥200 mm size class (242 mm) was captured in the side channel during the 2014 sampling (Figure 12). No rainbow trout were captured in the Lee Vining Creek side channel in 2014. This was the sixth consecutive year that no age-0 rainbow trout were captured in the side channel.

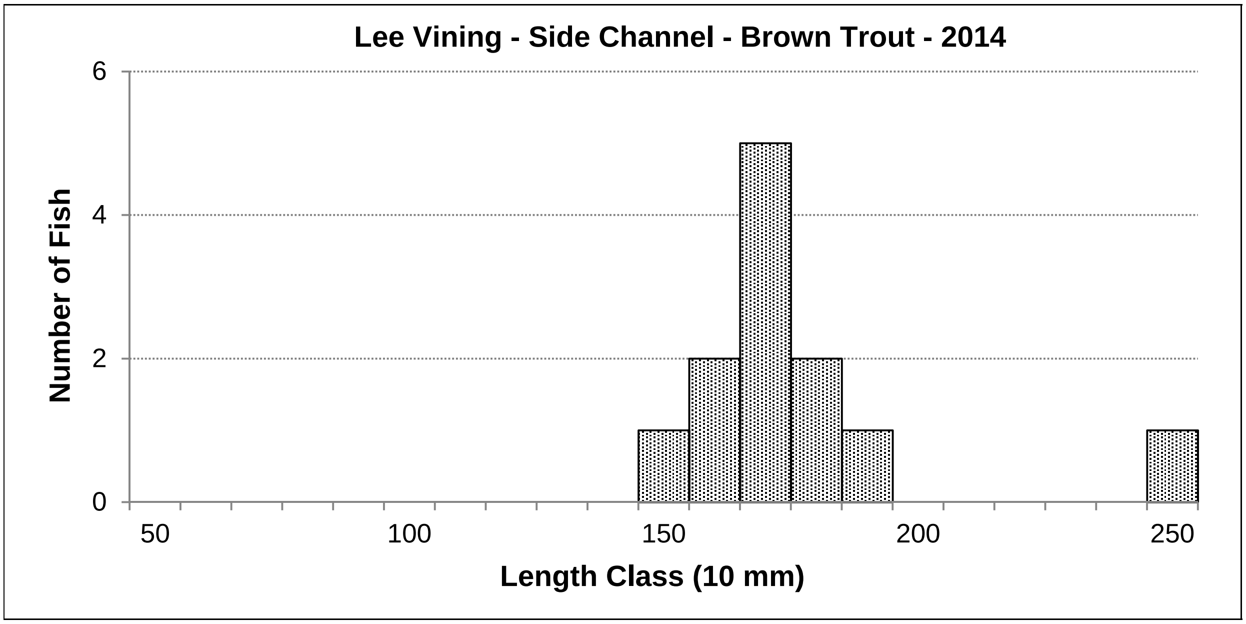


Figure 12. Length-frequency histogram of captured brown trout in the side channel section of Lee Vining Creek, September 10th, 2014.

Walker Creek

In 2014, a total of 185 brown trout were captured in two electrofishing passes in the Walker Creek section (345 brown trout were captured in 2013) (Table 4). Of these, 50 brown trout or 27% were age-0 fish ranging in size from 64 mm to 124 mm (Figure 16). The 2014 age-0 brown trout estimate for Walker Creek was 56 fish, a 76% decrease from the 2013 estimate of 236 age-0 brown trout. The 2014 standard error equaled 8.5% of the estimate.

Brown trout in the 125-199 mm size class (114 fish) accounted for 62% of the total catch in 2013 (compared to 28% in 2013). The population estimate for brown trout in the 125-199 mm size class was 116 trout with a standard error of <1% of the estimate (Table 4).

Brown trout ≥200 mm in length (21 fish) accounted for 11% of the total catch in 2013 (was 6% in 2013). The population estimate for this size class was 21 brown trout with a standard error of <1% of the estimate (Table 4). The largest brown trout captured in Walker Creek in 2014 was 245 mm in length (Figure 16).

A single rainbow trout was also captured in Walker Creek during the 2014 electrofishing. This fish was 184 mm in length and probably migrated out of Walker Lake downstream into the sampling section. Over the 16 years of annual fish sampling only four trout other than brown trout have been captured in Walker Creek: in 2002 a single rainbow trout, in 2006 a single brook trout, in 2013 a single rainbow trout, and in 2014 a single rainbow trout.

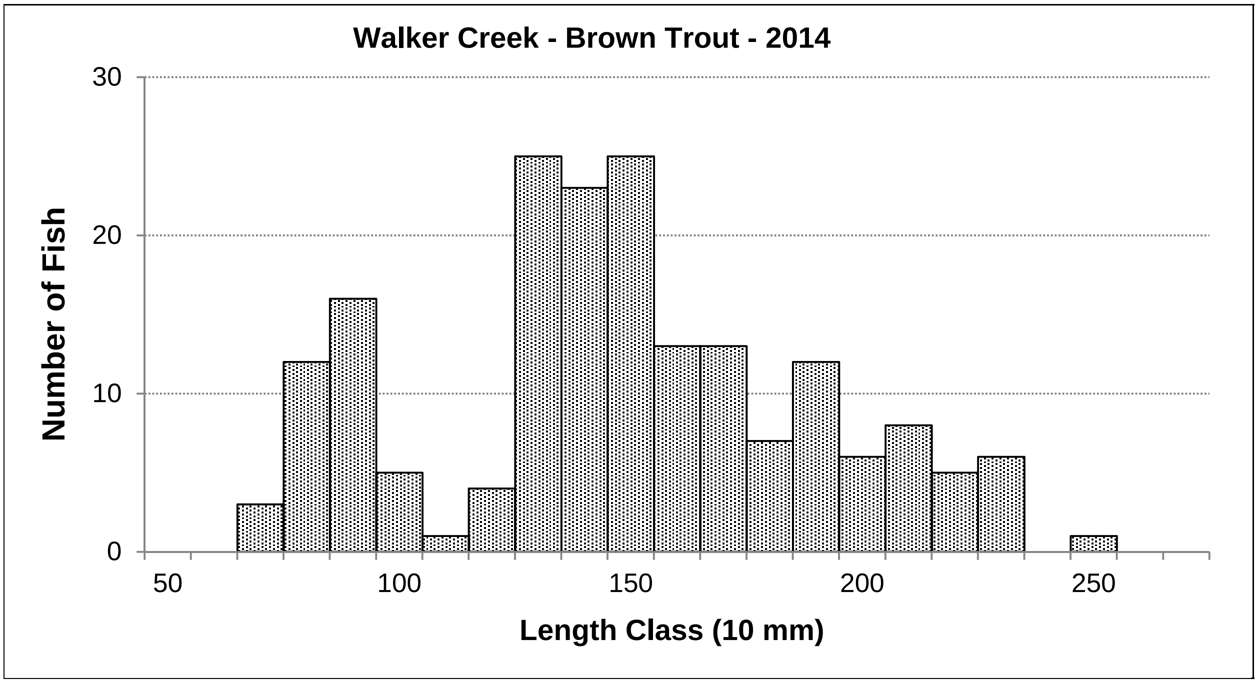


Figure 13. Length-frequency histogram of captured brown trout in Walker Creek, September 10th, 2014.

Table 4. Depletion estimates made in the side channel section of Lee Vining Creek and Walker Creek during September 2014 showing number of trout captured in each pass, estimated number, probability of capture (P.C.) by species and size class.

Stream - Section Date **Species**	Size Class (mm)	Removals	Removal Pattern	**Estimate**	P.C.
Lee Vining Creek- Side Channel B-1					
Brown Trout					
	0 - 124 mm	2	0 0	**0**	1.00
	125 - 199 mm	2	11 0	**11**	1.00
	200 + mm	2	1 0	**1**	1.00
Walker Creek - above old Hwy 395 - 9/11/2013					
Brown Trout					
	0 - 124 mm	2	38 12	**56**	0.68
	125 - 199 mm	2	101 13	**116**	0.87
	200 + mm	2	19 2	**21**	0.89

Catch of Rainbow Trout in Rush and Lee Vining Creeks

Beginning with the 2008 annual report, rainbow trout catch numbers have largely been reported for Rush Creek. This decision was made because rainbow trout usually accounted for <5% of the total catch in Rush Creek. In 2011 GLR spilled, carrying hatchery-origin rainbow trout out of the reservoir resulting in rainbow trout accounting for 8% of the total catch in 2011, the highest ever sampled in Rush Creek. In 2012, rainbow trout accounted for 5% of the total catch in Rush Creek. Although there were only 10 fewer rainbow trout captured in 2012 compared to 2011 the total number of trout in Rush Creek captured increased from 3,352 trout in 2011 to 4,697 in 2012 thus driving down the percent-catch of rainbow trout. In 2013, the rainbow trout catch in Rush Creek was down to 66 fish versus 3,035 brown trout, thus rainbow trout comprised 2% of the trout captured (66 rainbow trout/3,101 total trout). In 2014, the rainbow trout comprised 0.75% of the Rush Creek catch (15 rainbow trout/1,996 total trout). Given the California Department of Fish and Wildlife's current policy of stocking sterile catchable rainbow trout, it is unlikely that future rainbow trout numbers will approach 5% of the total fish catch in Rush Creek unless another major spill occurs from GLR during a wet RY.

Rainbow trout numbers in Lee Vining Creek have been variable over the last 14 years. Sufficient numbers of age-0 rainbow trout were captured in the main channel to generate population estimates for only five of the 14 years sampled (Table 5). Adequate numbers of age-1 and older rainbow trout were captured in the main channel to generate population estimates six of the 14 years sampled (Table 6). The side channel produced enough numbers of age-0 and age-1 and older rainbow trout to generate population estimates for six of the 15 years sampled (Tables 7 and 8). However, no age-0 rainbow trout have been caught in the side channel in the past six years and no age-1 and older rainbows have been caught in the past four years (Tables 7 and 8).

Due to rainbow trout encompassing a large portion (10-40%) of the Lee Vining Creek fishery, an effort has been made to generate density and biomass values using all data available. In years when adequate numbers of rainbows have been captured, statistically valid density and biomass estimates have been generated. In years when less than adequate numbers of rainbow trout have been captured, catch numbers have been used to generate density and biomass estimates. While catch numbers are not statistically valid they are consistently lower than statistically valid estimates and allow for comparison between years (Tables 5-8).

Table 5. Numbers of age-0 rainbow trout caught in Lee Vining Creek main channel section, 2000-2014.

Sample Year	Area of Sample Section (Ha)	Number of Trout on Marking Run	Number of Trout on Capture Run	Number of Recap Trout	Pop Estimate	Estimated Number of Trout per Hectare	Number of Trout Caught (Catch)	Catch per Hectare
2014	**0.1403**	**4**	**4**	**2**	**NP**	**NP**	**6**	**43**
2013	0.1454	19	12	5	40	275	26	179
2012	0.1279	155	138	67	318	2,494	226	1,773
2011	0.1428	1	0	0	NP	NP	1	7
2010	0.1505	0	0	0	0	0	0	0
2009	0.1505	4	4	0	NP	NP	8	53
2008	0.1377	17	31	9	57	414	39	283
2007	0.0884	42	56	22	106	1,199	76	860
2006	NS*	--	--	--	--	--	--	--
2005	0.0744	0	0	0	0	0	0	0
2004	0.0744	1	0	0	NP	NP	1	13
2003	0.0744	0	0	0	0	0	0	0
2002	0.0744	0	1	0	NP	NP	1	13
2001	0.0898	3	5	1	NP	NP	7	78
2000	0.0898	0	1	0	NP	NP	1	22

*NS stands for not sampled due to high flows

Table 6. Numbers of age-1 and older rainbow trout caught in Lee Vining Creek main channel section, 2000-2014.

Sample Year	Area of Sample Section (Ha)	Number of Trout on Marking Run	Number of Trout on Capture Run	Number of Recap Trout	Pop Estimate	Estimated Number of Trout per Hectare	Number of Trout Caught (Catch)	Catch per Hectare
2014	**0.1403**	**24**	**24**	**12**	**47**	**335**	**36**	**257**
2013	0.1454	61	45	29	120	826	77	530
2012	0.1279	7	7	5	NP	NP	9	71
2011	0.1428	5	8	5	NP	NP	8	56
2010	0.1505	12	9	7	15	100	14	93
2009	0.1505	39	32	12	98	651	59	392
2008	0.1377	71	64	37	129	936	98	712
2007	0.0884	3	5	1	NP	NP	7	79
2006	NS*	--	--	--	--	--	--	--
2005	0.0744	3	3	0	NP	NP	6	81
2004	0.0744	2	2	2	NP	NP	2	27
2003	0.0744	5	6	5	NP	NP	6	81
2002	0.0744	10	10	7	14	188	13	175
2001	0.0898	9	8	4	NP	NP	13	145
2000	0.0898	1	3	0	NP	NP	4	45

*NS stands for not sampled due to high flows

Table 7. Numbers of age-0 rainbow trout caught in Lee Vining Creek side channel section, 2000-2014.

Sample Year	Area of Sample Section (Ha)	Number of Trout Caught on Pass #1	Number of Trout Caught on Pass #2	Number of Trout Caught on Pass #3	Pop Estimate	Estimated Number of Trout per Hectare	Number of Trout Caught (Catch)	Catch per Hectare
2014	**0.0191**	**0**	**0**	**--**	**0**	**0**	**0**	**0**
2013	0.0195	0	0	--	0	0	0	0
2012	0.0365	0	0	--	0	0	0	0
2011	0.0507	0	0	--	0	0	0	0
2010	0.0507	0	0	--	0	0	0	0
2009	0.0488	0	0	--	0	0	0	0
2008	0.0488	5	2	--	7	143	7	143
2007	0.0488	4	0	--	NP	NP	4	82
2006	0.0761	46	26	--	100	1,314	72	946
2005	0.0936	0	0	--	0	0	0	0
2004	0.0936	82	30	--	127	1,357	112	1,197
2003	0.0936	0	0	--	0	0	0	0
2002	0.0936	28	17	--	64	684	45	481
2001	0.1310	69	23	--	102	779	92	702
2000	0.0945	32	15	--	57	603	47	497

Table 8. Numbers of age-1 and older rainbow trout caught in Lee Vining Creek side channel section, 2000-2014.

Sample Year	Area of Sample Section (Ha)	Number of Trout Caught on Pass #1	Number of Trout Caught on Pass #2	Number of Trout Caught on Pass #3	Pop Estimate	Estimated Number of Trout per Hectare	Number of Trout Caught (Catch)	Catch per Hectare
2014	**0.0191**	**0**	**0**	**--**	**0**	**0**	**0**	**0**
2013	0.0195	0	0	--	0	0	0	0
2012	0.0365	0	0	--	0	0	0	0
2011	0.0507	0	0	--	0	0	0	0
2010	0.0507	1	0	--	1	20	1	20
2009	0.0488	15	0	--	15	307	15	307
2008	0.0488	3	1	--	4	82	4	82
2007	0.0488	6	0	--	NP	NP	6	123
2006	0.0761	5	0	--	NP	NP	5	66
2005	0.0936	7	2	--	9	96	9	96
2004	0.0936	5	0	--	NP	NP	5	53
2003	0.0936	13	0	--	NP	NP	13	139
2002	0.0936	29	4	--	33	353	33	353
2001	0.1310	38	3	--	41	313	41	313
2000	0.0945	9	0	--	NP	NP	9	95

Relative Condition of Brown Trout

After Log_{10} transformations were performed on the lengths and weights of captured brown trout ≥ 100 mm, and a simple linear regression analysis was then performed. All sections had r^2 values 0.98 or greater, indicating that length was strongly correlated with weight (Table 9).

Table 9. Regression statistics for $\log_{10}$ transformed length (L) to weight (WT) for brown trout 100 mm and longer captured in Rush Creek by sample section and year. The 2014 regression equations are in ***bold*** type.

Section	Year	N	Equation	r^2	P
Bottomlands	***2014***	***238***	$\boldsymbol{\text{Log}_{10}(WT) = 3.0072*\text{Log}_{10}(L) - 5.0334}$	***0.98***	***<0.01***
	2013	247	$\text{Log}_{10}(WT) = 2.7997*\text{Log}_{10}(L) - 4.591$	0.98	<0.01
	2012	495	$\text{Log}_{10}(WT) = 2.8149*\text{Log}_{10}(L) - 4.6206$	0.98	<0.01
	2011	361	$\text{Log}_{10}(WT) = 2.926*\text{Log}_{10}(L) - 4.858$	0.99	<0.01
	2010	425	$\text{Log}_{10}(WT) = 2.999*\text{Log}_{10}(L) - 5.005$	0.99	<0.01
	2009	511	$\text{Log}_{10}(WT) = 2.920*\text{Log}_{10}(L) - 4.821$	0.99	<0.01
	2008	611	$\text{Log}_{10}(WT) = 2.773*\text{Log}_{10}(L) - 4.524$	0.99	<0.01
Upper Rush	***2014***	***613***	$\boldsymbol{\text{Log}_{10}(WT) = 2.9399*\text{Log}_{10}(L) - 4.8705}$	***0.99***	***<0.01***
	2013	522	$\text{Log}_{10}(WT) = 2.9114*\text{Log}_{10}(L) - 4.816$	0.99	<0.01
	2012	554	$\text{Log}_{10}(WT) = 2.8693*\text{Log}_{10}(L) - 4.721$	0.99	<0.01
	2011	547	$\text{Log}_{10}(WT) = 3.006*\text{Log}_{10}(L) - 5.014$	0.99	<0.01
	2010	420	$\text{Log}_{10}(WT) = 2.995*\text{Log}_{10}(L) - 4.994$	0.99	<0.01
	2009	612	$\text{Log}_{10}(WT) = 2.941*\text{Log}_{10}(L) - 4.855$	0.99	<0.01
	2008	594	$\text{Log}_{10}(WT) = 2.967*\text{Log}_{10}(L) - 4.937$	0.99	<0.01
	2007	436	$\text{Log}_{10}(WT) = 2.867*\text{Log}_{10}(L) - 4.715$	0.99	<0.01
	2006	485	$\text{Log}_{10}(WT) = 2.99*\text{Log}_{10}(L) - 4.98$	0.99	<0.01
	2005	261	$\text{Log}_{10}(WT) = 3.02*\text{Log}_{10}(L) - 5.02$	0.99	<0.01
	2004	400	$\text{Log}_{10}(WT) = 2.97*\text{Log}_{10}(L) - 4.94$	0.99	<0.01
	2003	569	$\text{Log}_{10}(WT) = 2.96*\text{Log}_{10}(L) - 4.89$	0.99	<0.01
	2002	373	$\text{Log}_{10}(WT) = 2.94*\text{Log}_{10}(L) - 4.86$	0.99	< 0.01
	2001	335	$\text{Log}_{10}(WT) = 2.99*\text{Log}_{10}(L) - 4.96$	0.99	< 0.01
	2000	309	$\text{Log}_{10}(WT) = 3.00*\text{Log}_{10}(L) - 4.96$	0.98	< 0.01
	1999	317	$\text{Log}_{10}(WT) = 2.93*\text{Log}_{10}(L) - 4.84$	0.98	< 0.01

Table 9 (continued).

Section	Year	N	Equation	R^2	P
MGORD	***2014***	***399***	**$\text{Log}_{10}(\text{WT}) = 2.9805*\text{Log}_{10}(\text{L}) – 4.9827$**	**0.98**	**<0.01**
	2013	431	$\text{Log}_{10}(\text{WT}) = 2.8567*\text{Log}_{10}(\text{L}) – 4.692$	0.98	<0.01
	2012	795	$\text{Log}_{10}(\text{WT}) = 2.9048*\text{Log}_{10}(\text{L}) – 4.808$	0.99	<0.01
	2011	218	$\text{Log}_{10}(\text{WT}) = 2.917*\text{Log}_{10}(\text{L}) – 4.823$	0.98	<0.01
	2010	694	$\text{Log}_{10}(\text{WT}) = 2.892*\text{Log}_{10}(\text{L}) – 4.756$	0.98	<0.01
	2009	689	$\text{Log}_{10}(\text{WT}) = 2.974*\text{Log}_{10}(\text{L}) – 4.933$	0.99	<0.01
	2008	862	$\text{Log}_{10}(\text{WT}) = 2.827*\text{Log}_{10}(\text{L}) – 4.602$	0.98	<0.01
	2007	643	$\text{Log}_{10}(\text{WT}) = 2.914*\text{Log}_{10}(\text{L}) – 4.825$	0.98	<0.01
	2006	593	$\text{Log}_{10}(\text{WT}) = 2.956*\text{Log}_{10}(\text{L}) – 4.872$	0.98	<0.01
	2004	449	$\text{Log}_{10}(\text{WT}) = 2.984*\text{Log}_{10}(\text{L}) – 4.973$	0.99	<0.01
	2001	769	$\text{Log}_{10}(\text{WT}) = 2.873*\text{Log}_{10}(\text{L}) – 4.719$	0.99	<0.01
	2000	82	$\text{Log}_{10}(\text{WT}) = 2.909*\text{Log}_{10}(\text{L}) – 4.733$	0.98	<0.01

Condition factors of brown trout 150 to 250 mm in length in 2014 decreased in three sections (MGORD, LV main channel, and LV side channel) from 2013’s values and increased in three sections from 2013’s values (Upper Rush, Bottomlands and Walker) (Figure 14). Walker Creek was the only sampling section in 2014 with a condition factor ≥1.00 (Figure 14).

The Upper Rush section had a condition factor of 0.99 in 2014, a slight increase from 0.97 in 2013 (Figure 14). The lowest condition factor value in the 14-year sampling history was 0.96 in 2007 and the value has been less than 1.00 for the three consecutive dry years.

The Bottomlands section had a condition factor of 0.96 in 2014, an increase from 0.91 in 2013 (Figure 14). The 2014 value was the first increase in condition factor after four consecutive decreases in the Bottomlands section since 2009’s value of 0.99.

The MGORD’s 2014 condition factor was 0.94, unchanged from the 2013 value. The value of 0.94 is still the lowest condition factor for 12 years of sample data for this section (Figure 14). For MGORD brown trout ≥300 mm in length, the 2014 condition factor was 0.95, an increase from 2013’s value of 0.90.

For the second consecutive year, brown trout in Lee Vining Creek’s main channel had a condition factor below 1.00 (Figure 14). The 2014 value was 0.93, down slightly from 2013’s value of 0.95 (Figure 14). For the past two years, rainbow trout 150 to 250 mm in length from the main channel also had a condition factor of less than 1.00 (Figure 15). Rainbow trout in 2014 once again had a better condition factor than the brown trout (0.96 versus 0.95) in the main channel of Lee Vining Creek (Figure 15).

In 2014, brown trout in Lee Vining Creek's side channel had a condition factor 0.89, a decrease from 2013's value of 0.93 (Figure 14). This was the third consecutive year in the 15 years of sampling the side channel that condition factors were less than 1.00. For the fourth year in a row, no rainbow trout were captured in the Lee Vining Creek side channel.

In Walker Creek, brown trout had a condition factor of 1.00 in 2014, an increase from 0.93 in 2013 (Figure 14).

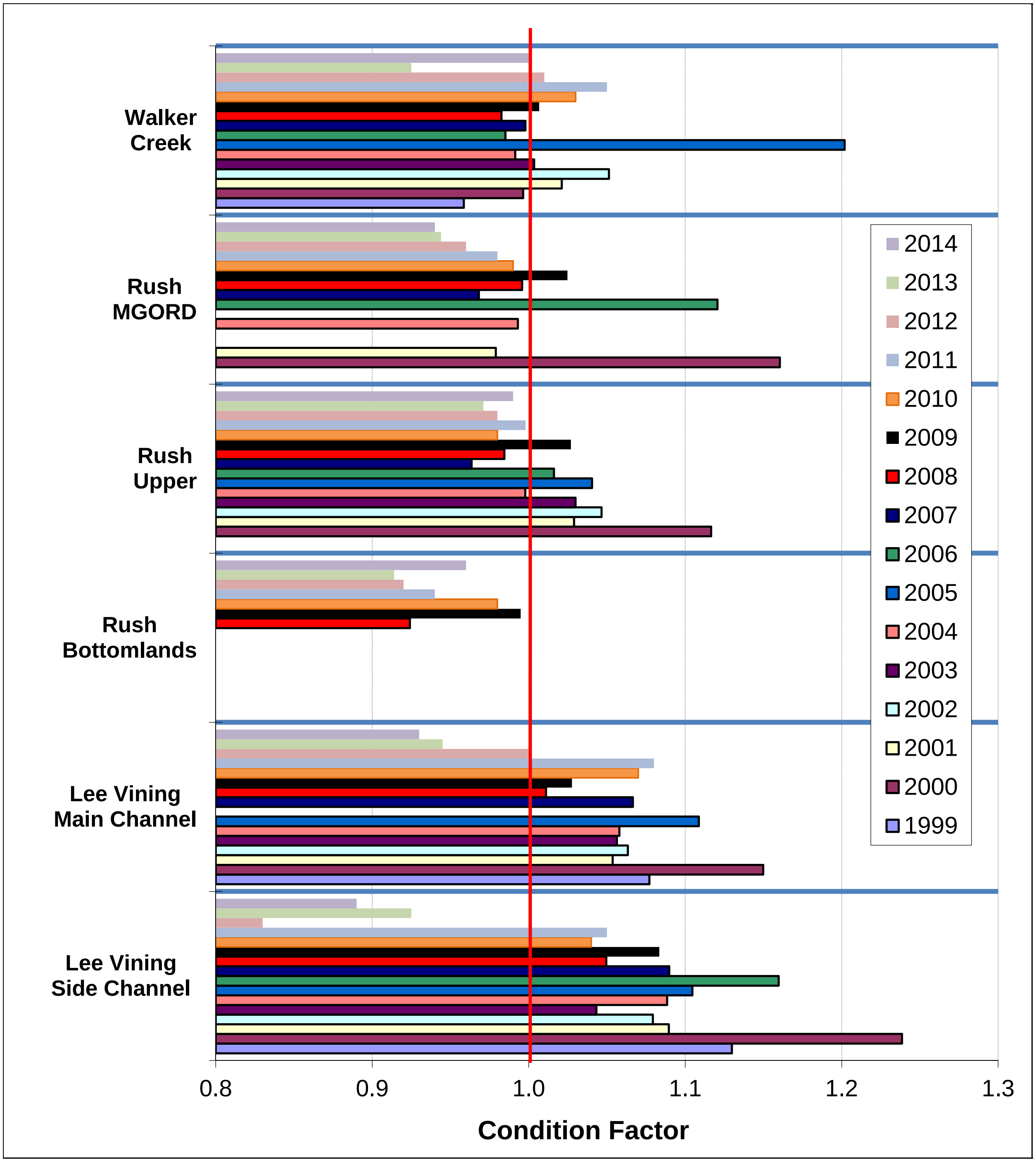


Figure 14. Condition factors for brown trout 150 to 250 mm in length from sample sections of Rush, Lee Vining, and Walker Creeks from 1999 to 2014.

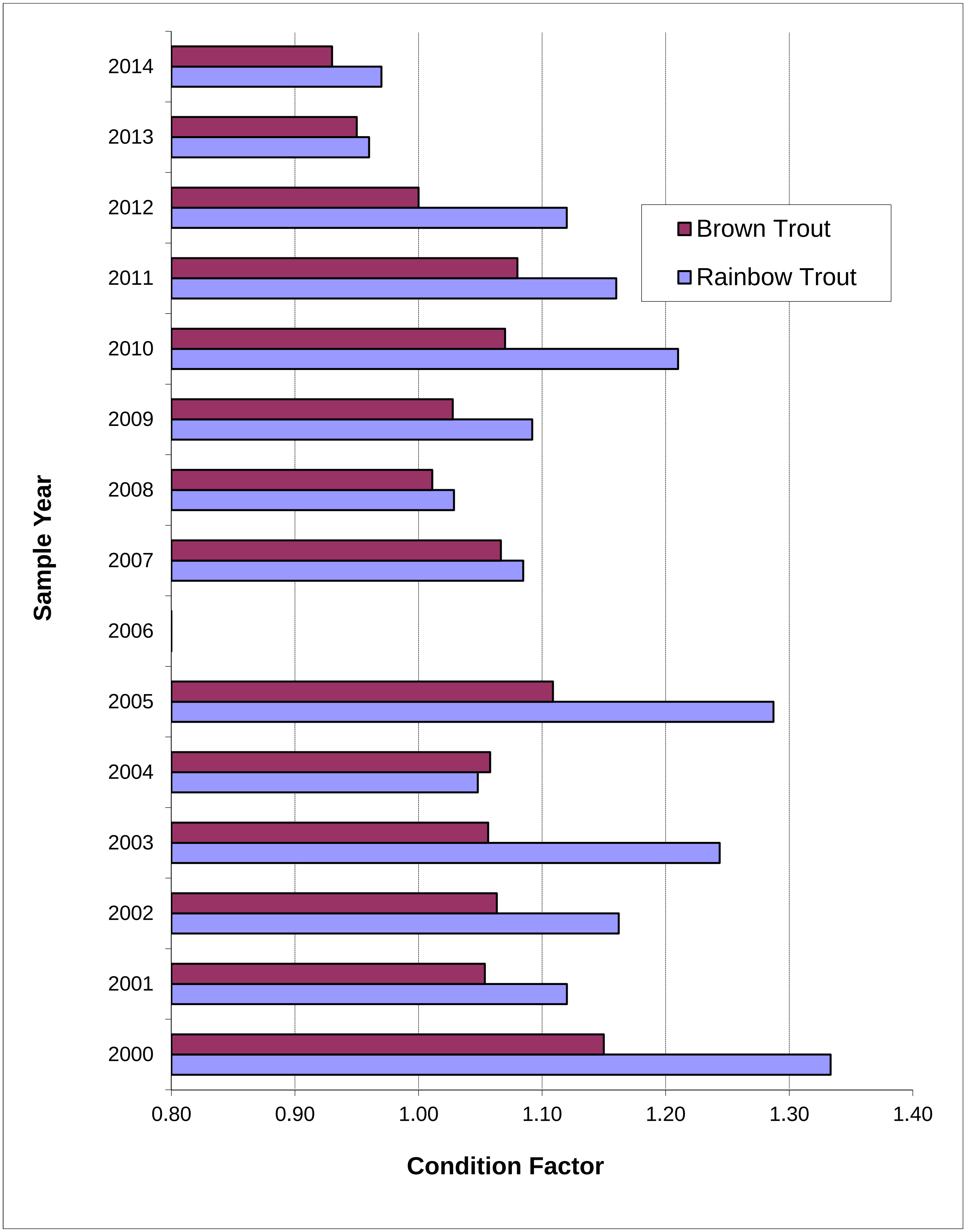


Figure 15. Comparison of condition factors for rainbow trout and brown trout 150 to 250 mm in length from the main channel section of Lee Vining Creek from 2000 to 2014. Main channel was not sampled in 2006 due to high flows.

Estimated Trout Densities

Age-0 Brown Trout

The Upper Rush section had an estimated density of 4,228 age-0 brown trout/ha in 2014, a decrease of 26% from 2013's estimate of 5,733 trout/ha (Figure 16). The 2014 density value on the Upper Rush section was 36% lower than the 15-year average of 6,571 age-0 brown trout/ha.

The Bottomlands section of Rush Creek had a density estimate of 569 age-0 brown trout/ha in 2014. This estimate was a 63% decrease in the number of trout/ha when compared to the 2013 estimate of 1,550 trout/ha (Figure 16). The 2014 and 2013 estimates were the lowest age-0 estimates since the start of sampling the Bottomlands section in 2008. When compared to the seven-year average of 2,154 age-0 brown trout/ha, the 2014 estimate was 74% lower.

In Walker Creek the 2014 density estimate of 1,527 age-0 brown trout/ha was a 79% decrease from the 2013 estimate of 7,193 trout/ha and was the fourth lowest in the 16-year sampling period for this section (Figure 16). The 2014 density estimate of 1,527 age-0 brown trout/ha was 57% lower than the 16-year average of 3,551 trout/ha (Figure 16).

In 2014, the age-0 brown trout density estimate in the main channel section of Lee Vining Creek was 1,726 trout/ha, which was a 44% decrease from the 2013 density estimate of 3,055 trout/ha (Figure 17). The 2014 estimate was slightly less than the 15-year average of 1,740 age-0 brown trout /ha.

No age-0 brown trout were captured in the Lee Vining Creek side channel during the 2014 sampling (Figure 17). In 2013, only a single age-0 brown trout was captured in the Lee Vining Creek side channel (Figure 17).

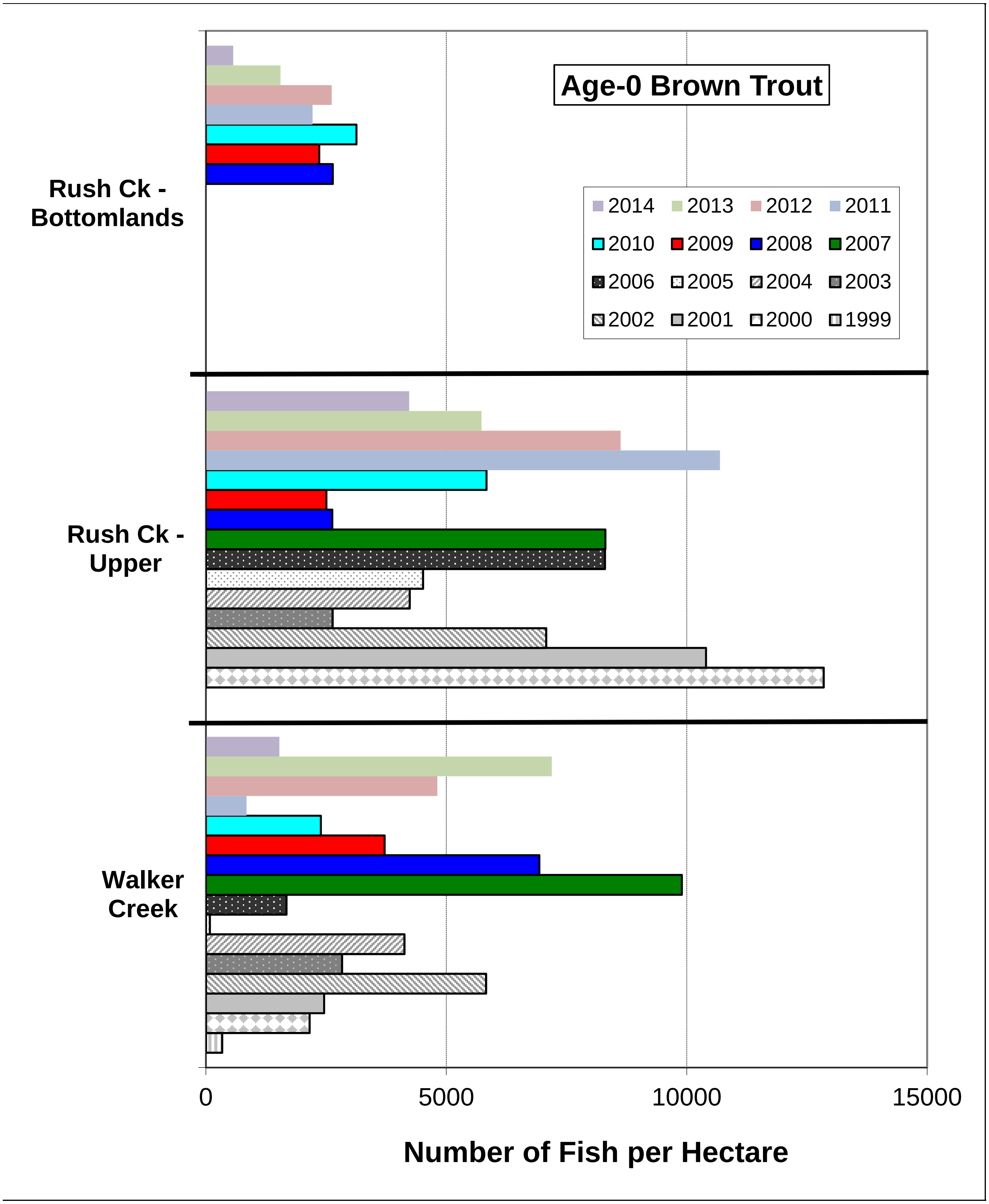


Figure 16. Estimated number of age-0 brown trout per hectare in Rush Creek and Walker Creek from 1999 to 2014.

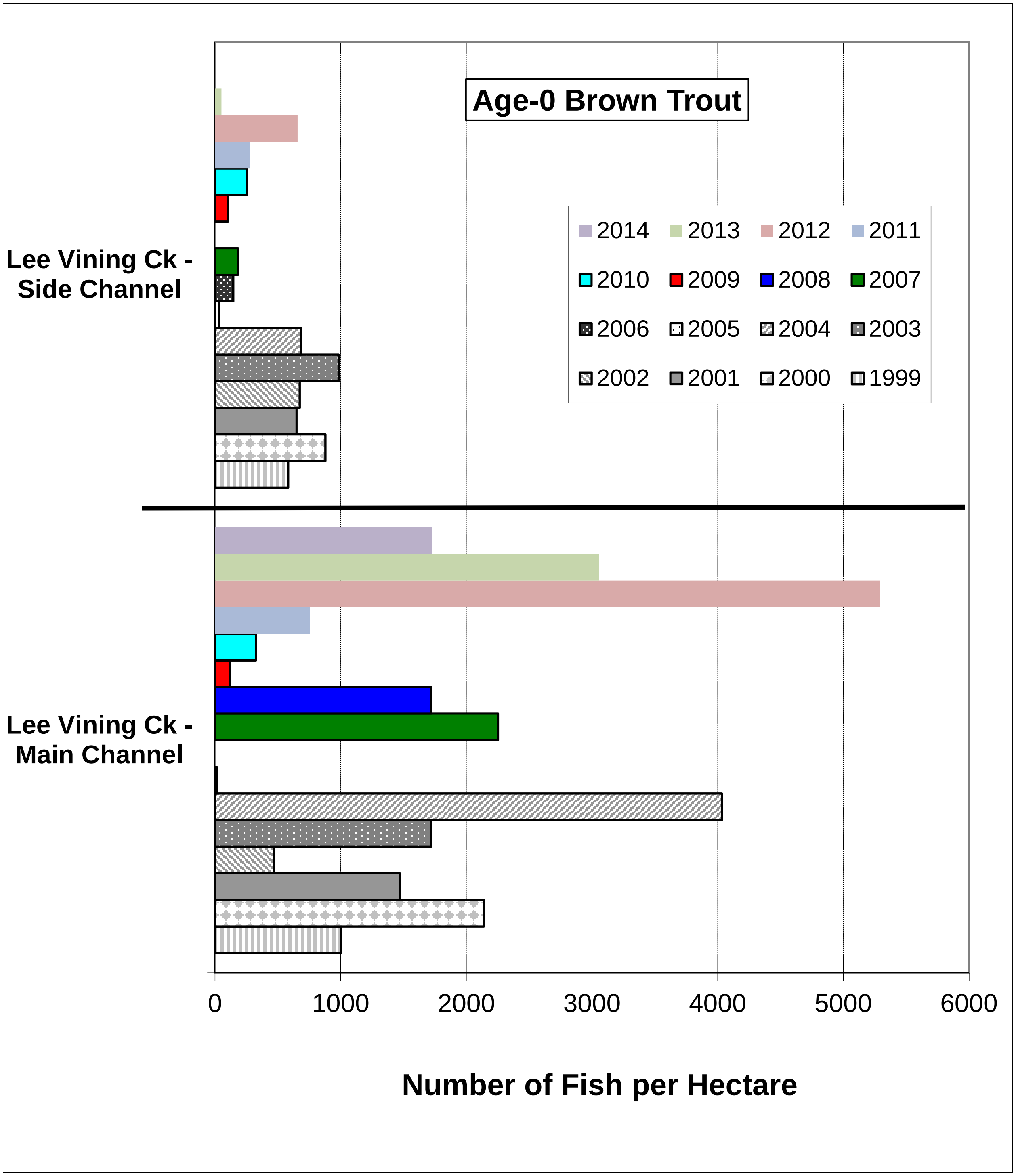


Figure 17. Estimated number of age-0 brown trout per hectare in Lee Vining Creek from 1999 to 2014.

Age-1 and older (aka Age-1+) Brown Trout

The Upper Rush section had an estimated density (number per hectare) of 2,125 age-1+ brown trout/ha in 2014, an increase of 31% from the 2013 estimate of 1,622 trout/ha (Figure 18). The 2014 density estimate of 2,125 age-1+ brown trout/ha was the second highest in the 16-year sampling period (Figure 18).

The Bottomlands section of Rush Creek produced a density estimate of 1,000 age-1+ brown trout/ha in 2014, an 8% decrease from the 2013 estimate of 1,089 trout/ha (Figure 18). The 2014 density estimate of age-1+ brown trout/ha was the lowest since the start of sampling the Bottomlands section in 2008 (Figure 18).

The 2014 density estimate for age-1+ brown trout for the Walker Creek section was 3,736 trout/ha which was a 7% increase from the 2013 estimate of 3,505 trout/ha (Figure 18). The 2014 density estimate of age-1+ brown trout was the highest estimate for the 16 years that Walker Creek has been sampled; the second consecutive year that the estimate was the section’s record high (Figure 18).

The 2014 density estimate for age-1+ brown trout in the Lee Vining main channel section was 2,225 trout/ha, an decrease of 9% from the 2,449 trout/ha in 2013. The 2014 estimate was the second highest density estimate for this section for the 15 seasons that estimates have been generated (2006 was not sampled due to high flows) (Figure 19).

In 2014, the side channel of Lee Vining Creek produced an estimated density of 630 age-1+ brown trout/ha which was the third highest estimate ever generated for this section, but was an 18% decrease from the 2013 estimate of 768 fish/ha (Figure 19). The 2014 estimate of 630 age-1+ brown trout/ha was more than twice the section’s 16-year average of 292 trout/ha (Figure 19).

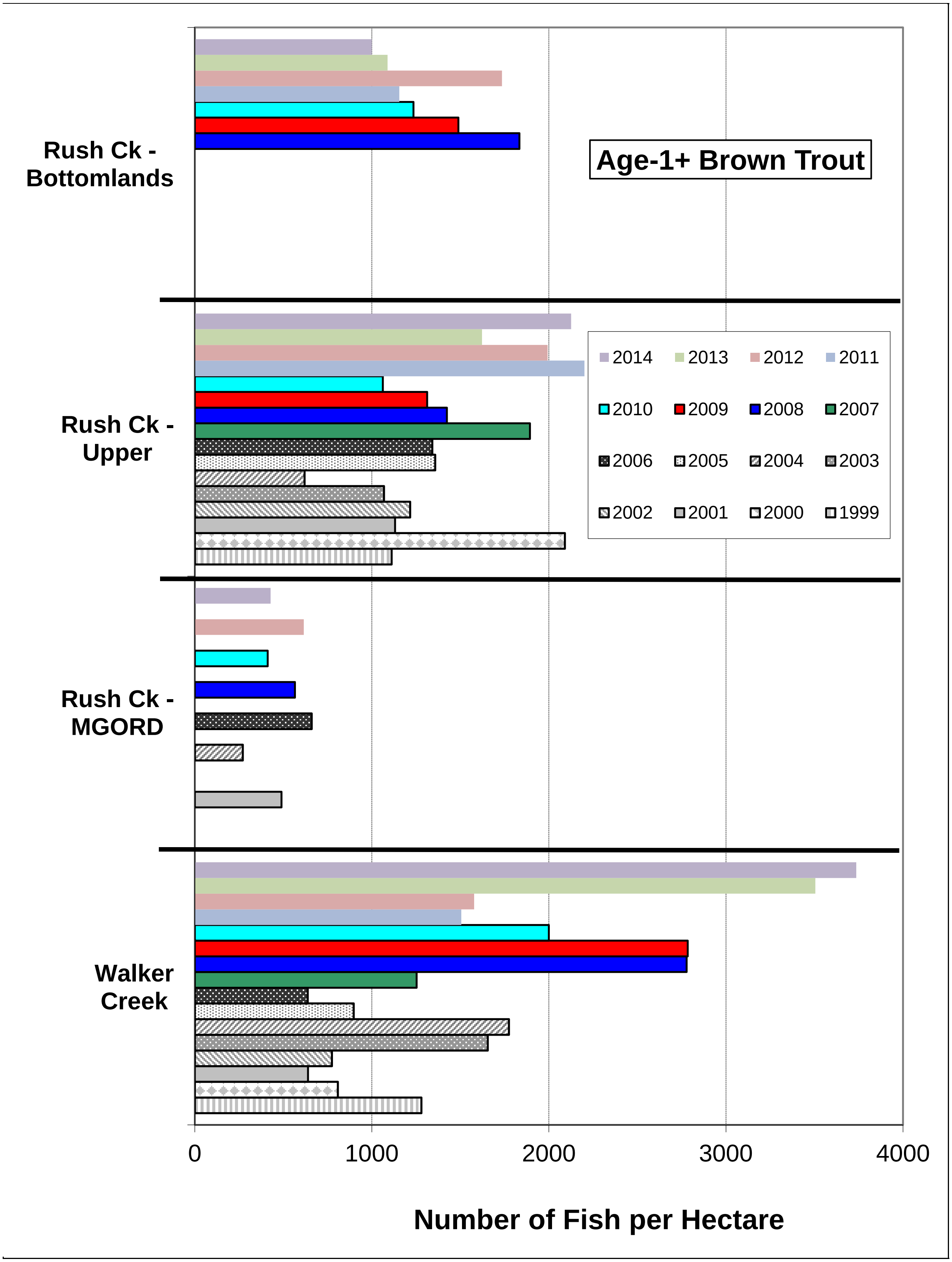


Figure 18. Estimated number of age-1 and older brown trout per hectare in sections of Rush and Walker Creeks from 1999 to 2014.

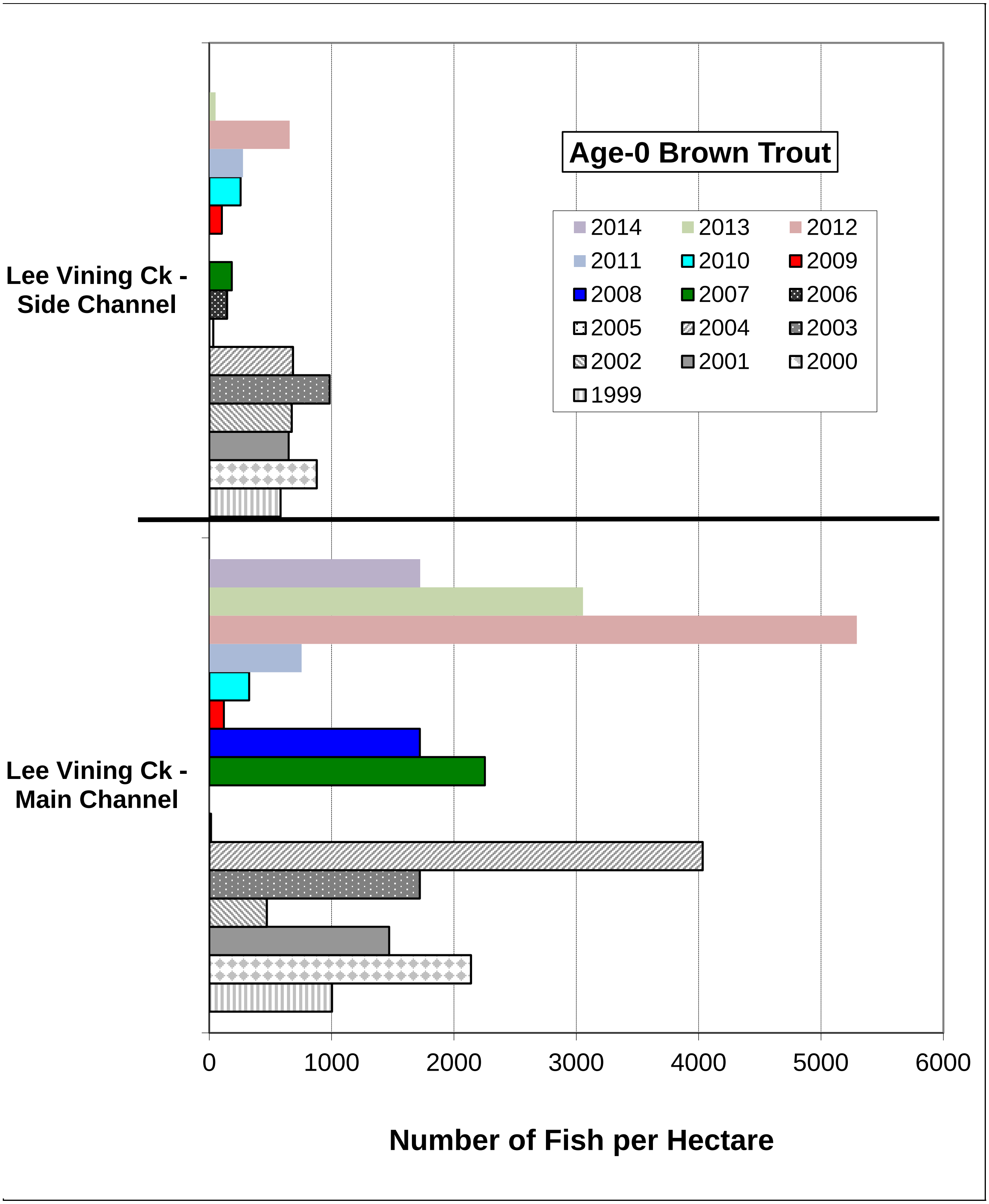


Figure 19. Estimated number of age-1 and older brown trout per hectare in sections of Lee Vining Creek from 1999 to 2014.

Age-0 Rainbow Trout

For the sixth consecutive year no age-0 rainbow trout were captured in the Lee Vining Creek side channel.

For the Lee Vining Creek main channel, the estimated densities of age-0 rainbow trout decreased by 84% from 275 trout/ha in 2013 to 43 trout/ha in 2014 (Figure 20). Between 2012 and 2014, the estimated densities of age-0 rainbow trout decreased by 98%, from 2,393 trout/ha to 43 trout/ha (Figure 20). In seven sampling years, insufficient numbers of age-0 rainbow trout were captured to generate population estimates (density estimates were derived from catch data) and in three sampling years no age-0 rainbow trout were captured in the main channel section of Lee Vining Creek (Figure 20).

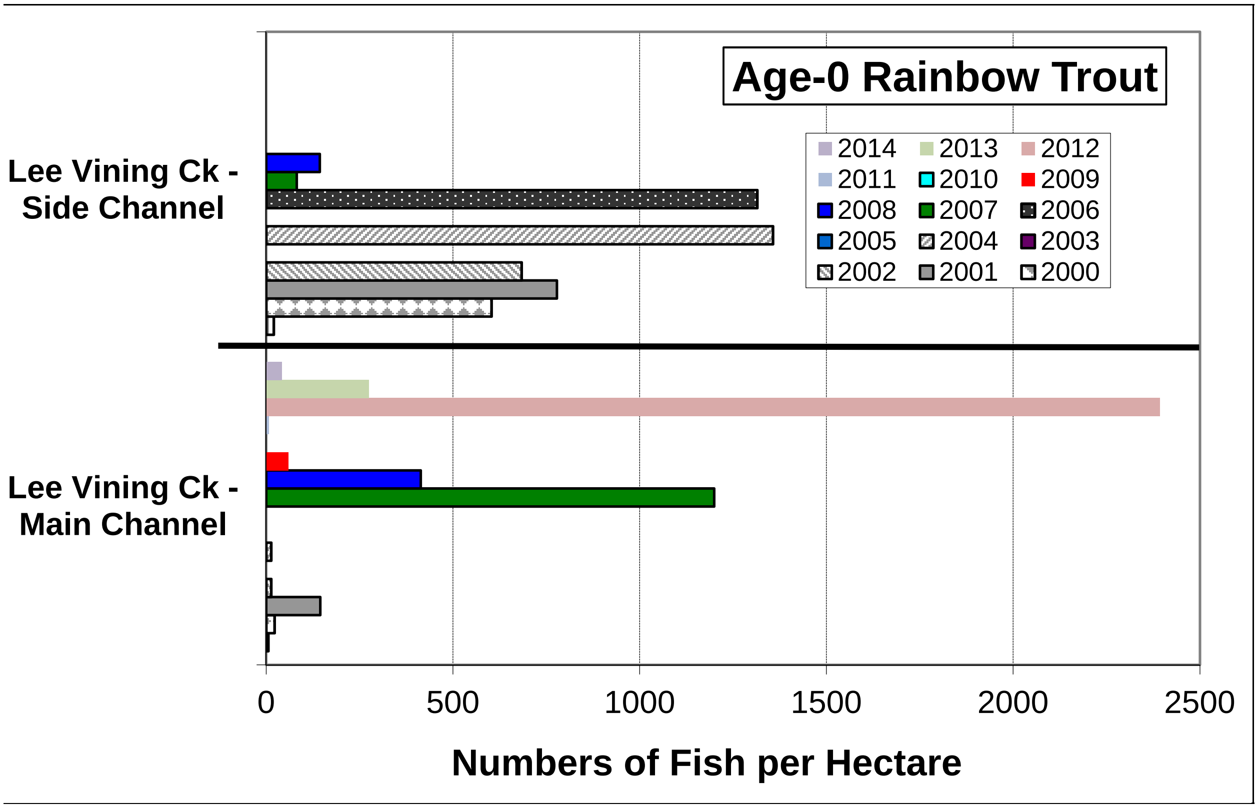


Figure 20. Estimated number of age-0 rainbow trout per hectare in sections of Lee Vining Creek from 1999 to 2014.

Age-1 and older (aka Age-1+) Rainbow Trout

For the fourth consecutive year no age-1 and older rainbow trout were captured in the Lee Vining Creek side channel.

For the Lee Vining Creek main channel, the estimated densities of age-1 and older rainbow trout decreased by 46% from 826 trout/ha in 2013 to 449 trout/ha in 2014 (Figure 21). The 2014 density estimate of age-1+ rainbow trout was the fourth highest in the 15 years in which data were collected in this section (Figure 21). Sampling years (1999-2001, 2003-2005, 2007 and 2011) produced insufficient numbers of age-1 and older rainbow trout to generate population estimates, thus these density estimates were derived from catch data.

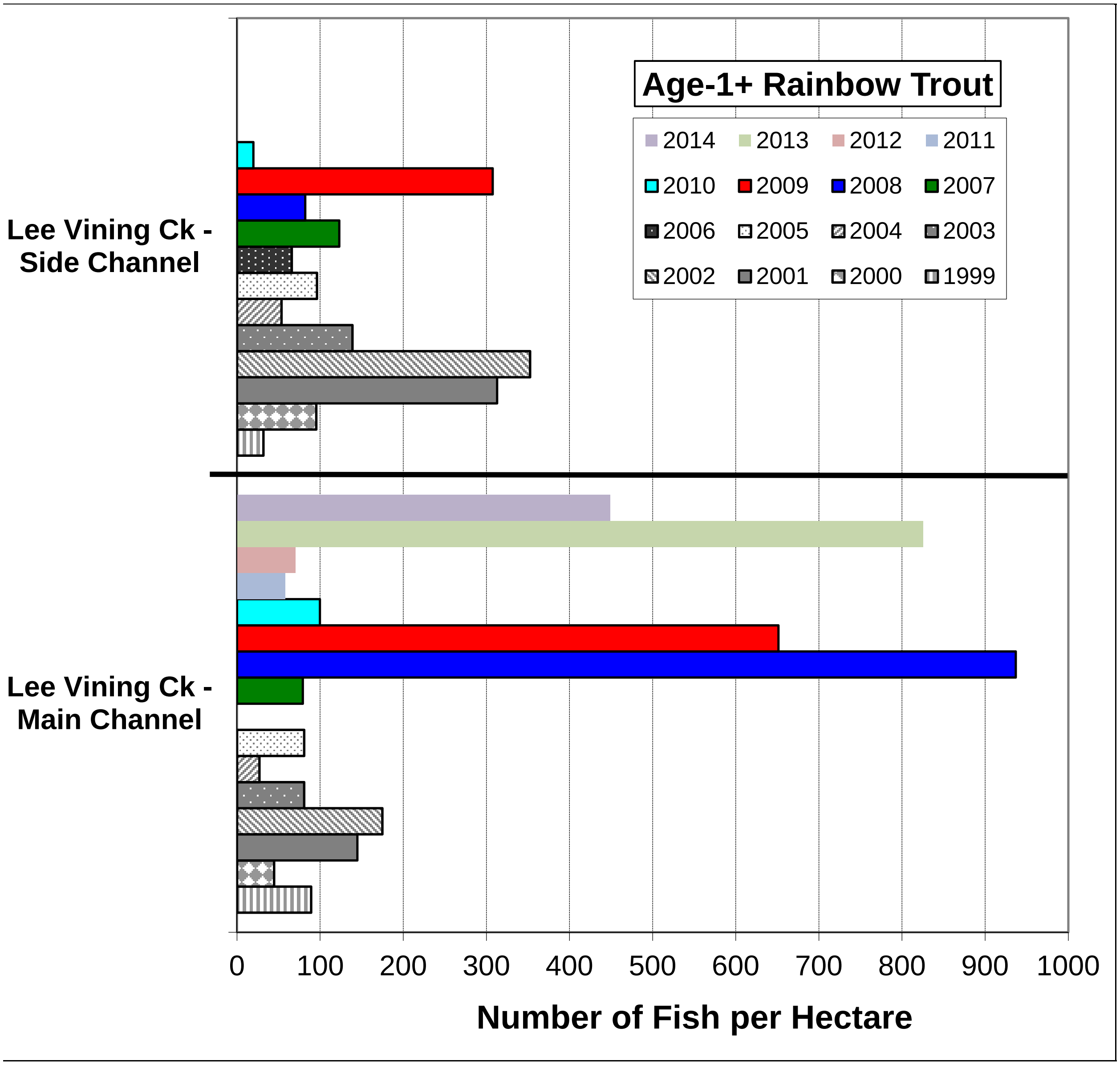


Figure 21. Estimated number of age-1 and older rainbow trout per hectare in sections of Lee Vining Creek from 1999 to 2014.

Estimated Trout Densities Expressed in Numbers per Unit Length

The Upper Rush section produced a total density estimate of 4,574 brown trout per kilometer in 2014 which was 30% lower than the 2013 estimate of 6,105 fish/km (Table 10). The estimated numbers of brown trout per kilometer have fallen for three straight years in the Upper Rush section. The estimated age-1+ brown trout density in 2014 was 1,530 brown trout/km which was a 14% increase from the 2013 estimate of 1,347 fish/km (Table 10).

The Bottomlands section in 2014 produced a total density estimate of 1,098 brown trout/km which was a 45% decrease from the 2013 estimate of 1,980 fish/km (Table 10). The estimated density of age-1+ brown trout in 2014 was 700 fish/km, a 14% decrease from the 2013 estimate of 817 fish/km (Table 10). In 2014, both the total numbers of brown trout/km and numbers of age-1+ brown trout/km were the lowest estimates for the seven-year sampling period in the Bottomlands section.

The Lee Vining Creek main channel produced a total density estimate of 2,444 rainbow and brown trout/km in 2014 (Table 11). The 2014 estimate was 35% less than the 2013 estimate of 3,765 rainbow trout and brown trout/km; however the 2014 value was still the third highest total density estimate for 14 sampling years. For age-1+ rainbow trout and brown trout combined, the estimated density was 1,471 fish/km in 2014, which was a 21% decrease from the 2013 estimate of 1,867 age-1+ fish/km (Table 11). The 2014 density estimate of age-1+ rainbow trout and brown trout per kilometer was the second highest recorded during the 14 years of sampling the Lee Vining Creek main channel section.

The Lee Vining side channel produced a total density estimate of 95 brown trout/km in 2014, a 27% decrease from the 2013 estimate of 131 fish/km (Table 11). For age-1+ brown trout, the 2014 density estimate was also 95 brown trout/km which was a 23% decrease from the 2013 density estimate 123 fish/km (Table 11).

The Lee Vining Creek main channel and the side channel densities were added in order to compare to the proposed termination criteria as discussed in the 2011 Annual Fisheries Report (Taylor and Knudson 2011). When combined, the two channels produced a total density estimate of 1,662 rainbow and brown trout/km in 2014, a decrease of 36% from the 2013 estimate of 2,588 rainbow and brown trout/km (Table 20). Age-1+ trout in these two channels produced an estimate of 1,013 rainbow and brown trout/km in 2014, a 22% decrease from the 2013 estimate of 1,302 fish/km.

Table 10. Total number of brown trout per kilometer of stream channel for Rush Creek sample sections from 2000 to 2014. The value within (#) denotes the number of age-1 and older trout per kilometer.

Collection Location	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Rush Creek, Upper Rush	11,054 (1,547)	8,535 (837)	6,137 (900)	2,740 (791)	3,881 (495)	5,032 (1,167)	7,905 (1,100)	8,698 (1,621)	3,607 (1,267)	3,444 (1,186)	5,726 (881)	10,821 (1,833)	8,288 (1,556)	6,105 (1,347)	4,574 (1,530)
Rush Creek, Bottomlands	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3,579 (1,467)	2,961 (1,146)	3,405 (963)	2,725 (929)	3,208 (1,279)	1,980 (817)	1,098 (700)

Table 11. Total number of brown and rainbow trout per kilometer of stream channel for Lee Vining Creek sample sections from 2000 to 2014. The value within (#) denotes the number of age-1 and older trout per kilometer.

Collection Location	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Lee Vining, Main Channel	674 (337)	1,333 (567)	883 (729)	1,181 (355)	936 (568)	917 (910)	No Sample due to high flow	2,103 (148)	2,357 (1,204)	1,192 (1,023)	518 (326)	727 (258)	4,361 (506)	3,765 (1,867)	2,444 (1,471)
Lee Vining, Side Channel	853 (112)	623 (287)	731 (369)	626 (154)	1,144 (165)	169 (154)	618 (48)	129 (62)	103 (67)	133 (108)	103 (36)	159 (87)	257 (123)	131 (123)	95 (95)
LV Main + LV Side Additive Approach	764 (225)	978 (427)	807 (549)	904 (255)	1,040 (367)	543 (532)	N/A	1,116 (105)	1,230 (636)	663 (566)	311 (181)	443 (173)	2,668 (348)	2,588 (1,302)	1,662 (1,013)

Estimated Trout Standing Crop Comparisons

The estimated standing crop for brown trout in the Upper Rush section was 167 kg/ha in 2014; which was a 19% increase from the 2013 estimate of 140 kg/ha and a 6% decrease from the 2012 estimate of 178 kg/ha (Table 12 and Figure 22). When compared to the 16-year average of 152 kg/ha, the 2014 standing crop estimate was approximately 10% greater (Figure 22).

The estimated standing crop for brown trout in the Bottomlands section of Rush Creek was 52 kg/ha in 2014; which was a 5% decrease from the 2013 estimate of 55/kg and a 50% decrease from the 2012 estimate of 103 kg/ha (Table 12 and Figure 22). When compared to the seven-year average of 92 kg/ha, the 2014 standing crop estimate was approximately 44% lower (Figure 22).

Although there is not a standing crop termination criterion for Walker Creek, an estimate was still generated for this annually-sampled section. The estimated standing crop for brown trout in Walker Creek was 189 kg/ha in 2014; a 3% decrease from the 2013 estimate of 194 kg/ha and a 21% increase from the 2012 estimate of 156/kg (Table 12 and Figure 22). The 2014 standing crop estimate was the second highest value recorded in Walker Creek over the 16-year sample period and the long-term average for this period is 129 kg/ha, and this average is higher than all Rush Creek sections except for Upper Rush (152 kg/ha).

The Lee Vining Creek main channel in 2014 produced a total standing crop of 140 kg/ha for both rainbow and brown trout (Table 13 and Figure 23). The 2014 total estimate was a 24% decrease from the 2013 estimate of 184 kg/ha and a 19% decrease from the 2012 estimate of 173 kg/ha (Table 13). The 2014 brown trout standing crop estimate was 113 kg/ha and the rainbow trout standing crop estimate was 27 kg/ha. In 2014, the brown trout estimated standing crop decreased from the 2013 estimate by 15% and the 2014 rainbow trout estimated standing crop decreased by 47% from the 2013 estimate. The 2014 total standing crop of 140 kg/ha was 10 kg/ha greater than the 15-year average of 130 kg/ha.

The Lee Vining Creek side channel produced a brown trout standing crop estimate of 30 kg/ha in 2014 which was a 15% increase compared to the 2013 estimate of 26 kg/ha (Table 13 and Figure 23). No rainbow trout were captured in the Lee Vining Creek side channel in 2014 and none have been sampled in the side channel section for four consecutive years (2011-2014).

When an additive standing crop estimate was generated for the Lee Vining Creek main channel and the side channel, the total standing crop estimate equaled 126 kg/ha for 2014, a 24% decrease from the 2013 estimate of 165 kg/ha (Table 13).

Table 12. Comparison of brown trout standing crop (kg/ha) estimates between 2012, 2013, and 2014 for Rush Creek sections.

Collection Location	**2012 Total Standing Crop (kg/ha)**	**2013 Total Standing Crop (kg/ha)**	**2014 Total Standing Crop (kg/ha)**	**Percent Change Between 2013 and 2014**
Rush Creek – Upper	178	140	167	+19%
Rush Creek - Bottomlands	103	55	52	-5%
Walker Creek	156	194	189	-3%

Table 13. Comparison of total (brown and rainbow trout) standing crop (kg/ha) estimates between 2012, 2013, and 2014 for the Lee Vining Creek sections.

Collection Location	**2012 Total Standing Crop (kg/ha)**	**2013 Total Standing Crop (kg/ha)**	**2014 Total Standing Crop (kg/ha)**	**Percent Change Between 2013 and 2014**
Lee Vining Creek - Main Channel	173	184	140	-24%
Lee Vining Creek - Side Channel	39	26	30	+15%
Lee Vining Creek – Main and Side Channel Combined	143	165	126	-24%

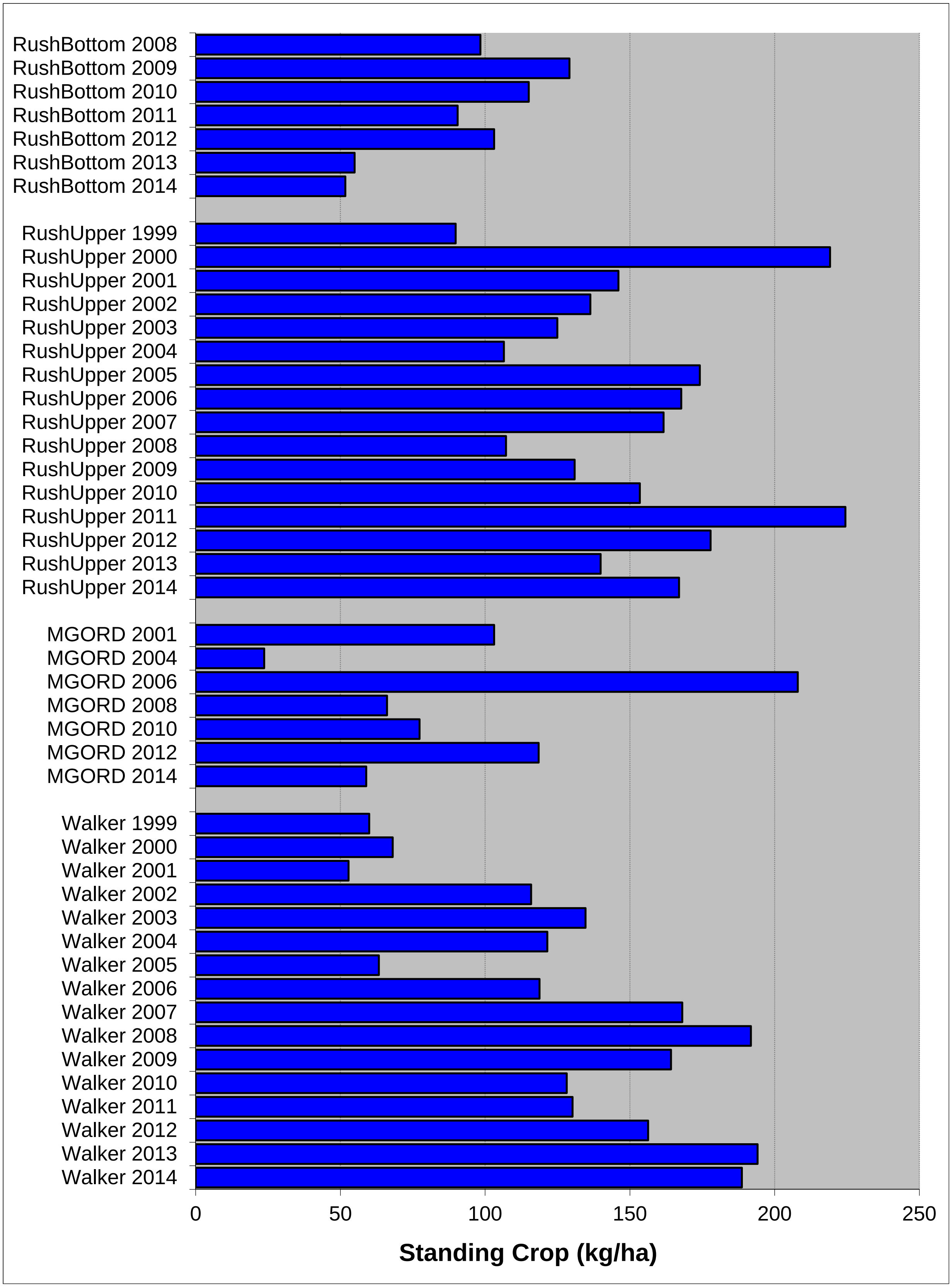


Figure 22. Estimated total standing crop (kilograms per hectare) of brown trout in Rush Creek sample sections from 1999 to 2014.

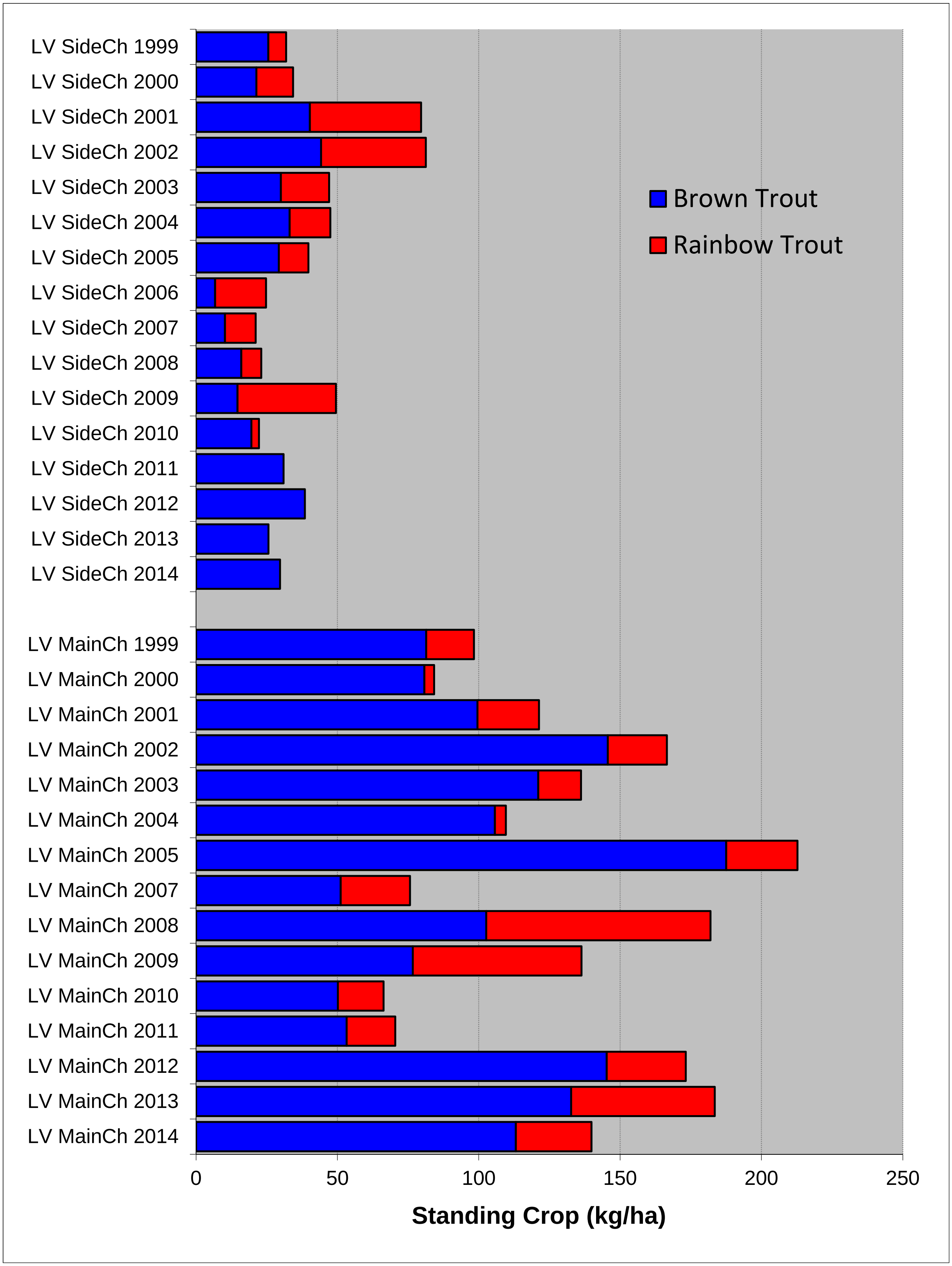


Figure 23. Estimated total standing crop (kilograms per hectare) of brown trout and rainbow trout (red) in Lee Vining Creek sample sections from 1999 to 2014.

Relative Stock Density (RSD) Results for Rush and Lee Vining Creeks

In the Upper Rush section, since the 2010 value of 34, the RSD-225 has steadily decreased to 23 in 2011, 20 in 2012, 14 in 2013, and 10 in 2014 (Table 14). The RSD-225 of 10 in 2014 was also lowest value for the 15-years of sampling mainly due to the low numbers of brown trout ≥225 mm (lowest total in past 14 years). The RSD-300 value was 1 in 2014, which has not changed for the past four sampling years (Table 14). Over the 15 sampling years, a total of 87 brown trout ≥300 mm were captured in the Upper Rush Creek section, an average of 5.8 fish per year (Table 14).

In the Bottomlands section of Rush Creek, since the 2010 value of 27, the RSD-225 has steadily decreased to 18 in 2011, 11 in 2012, 4 in 2013, and 1 in 2014 (Table 14). In 2014, only two brown trout ≥225 mm were captured in the Bottomlands section and one of these was a large PIT-tagged fish that had moved downstream from the MGORD. The average number of brown trout ≥225 mm captured over the seven-year sampling history was 36 trout per year, with only six fish ≥225 mm captured in the past two years (Table 14). The extremely low RSD values in 2013 and 2014 along with the PIT tag data suggest that for a second consecutive year there was both poor survival of fish from age-2 to age-3 as well as poor growth rates of fish from age-1 to age-2 (from 2012 to 2013 and from 2013 to 2014).

In the MGORD, the RSD-225 value decreased between 2011 and 2013, but increased from 42 in 2013 to 53 in 2014 (Table 14). In 2014, the RSD-300 value was 7, the lowest ever recorded for the 13-year period (Table 14). The RSD-375 value in 2014 was 3, the lowest value since 2008 (Table 14). In 2014, only 29 brown trout ≥300 mm were captured during the two electrofishing passes. Of these 29 brown trout, 10 fish were ≥375 mm in length.

RSD values in Lee Vining Creek were generated for the main channel only and the main channel combined with the side channel (Table 15). The 2014, RSD-225 values increased compared to 2013, most likely due to the higher numbers of age-2 trout after the high abundance of age-1 brown trout in 2013. For the main channel section of Lee Vining Creek, the 2014 RSD-225 value of 14 was 50% of the 14-year average of 28 and a 65% decrease of the four-year average of 40 for sample years 2009-2012 (Table 15).

Table 14. RSD values for brown trout in Rush Creek sections from 2000 to 2014.

Sampling Location Rush Creek	Sample Year	Number of Trout ≥150 mm	Number of Trout ≥150-224 mm	Number of Trout 225-299 mm	Number of Trout 300-374 mm	Number of Trout ≥375 mm	RSD-225	RSD-300	RSD-375
Upper Rush	**2014**	**366**	**331**	**31**	**4**	**0**	**10**	**1**	
Upper Rush	2013	336	288	45	3	0	14	1	
Upper Rush	2012	354	284	66	3	1	20	1	
Upper Rush	2011	498	381	110	6	1	23	1	
Upper Rush	2010	308	202	97	7	2	34	3	1
Upper Rush	2009	372	322	43	5	2	13	2	1
Upper Rush	2008	227	189	31	6	1	17	3	
Upper Rush	2007	282	210	61	9	2	26	4	1
Upper Rush	2006	233	154	69	10	0	34	4	
Upper Rush	2005	202	139	56	5	2	31	3	
Upper Rush	2004	179	112	64	2	1	37	2	
Upper Rush	2003	264	216	45	2	1	18	1	
Upper Rush	2002	220	181	35	1	2	18	2	1
Upper Rush	2001	223	190	27	6	0	15	3	
Upper Rush	2000	182	158	22	2	0	13	1	
Bottomlands	**2014**	**154**	**152**	**1**	**0**	**1**	**1**	**1**	**1**
Bottomlands	2013	128	123	5	0	0	4	0	
Bottomlands	2012	325	290	34	1	0	11	0	
Bottomlands	2011	267	218	46	3	0	18	1	
Bottomlands	2010	307	225	81	1	0	27	0	
Bottomlands	2009	379	321	56	1	1	15	1	
Bottomlands	2008	160	141	19	0	0	12	0	
MGORD	**2014**	**388**	**184**	**175**	**19**	**10**	**53**	**7**	**3**
MGORD	2013	411	237	118	41	15	42	14	4
MGORD	2012	694	176	319	173	26	75	29	4
MGORD	2011	216	36	117	55	8	83	29	4
MGORD	2010	694	252	292	115	35	64	22	5
MGORD	2009	643	156	338	123	26	76	23	4
MGORD	2008	856	415	301	118	22	52	16	3
MGORD	2007	621	144	191	259	27	77	46	4
MGORD	2006	567	60	200	280	27	89	54	5
MGORD	2004	424	130	197	64	33	69	23	8
MGORD	2001	774	330	217	119	108	57	29	14

Table 15. RSD values for brown and rainbow trout in the Lee Vining Creek main channel and side channel sections from 2008 to 2014. RSD values for brown and rainbow trout in the Lee Vining Creek main channel section from 2000 to 2014.

Sampling Location Rush Creek	Sample Year	Number of Trout ≥150 mm	Number of Trout ≥150-224 mm	Number of Trout 225-299 mm	Number of Trout 300-374 mm	Number of Trout ≥375 mm	RSD-225	RSD-300
Main & Side	**2014**	**212**	**184**	**28**	**0**	**0**	**13**	**0**
Main & Side	2013	327	309	17	1	0	6	0
Main & Side	2012	128	87	39	2	0	32	2
Main & Side	2011	78	46	26	5	1	41	1
Main & Side	2010	68	31	35	2	0	54	3
Main & Side	2009	192	159	32	1	0	17	1
Main & Side	2008	252	242	19	0	0	8	0
Main Channel	**2014**	**200**	**173**	**27**	**0**	**0**	**14**	**0**
Main Channel	2013	325	308	16	1	0	5	0
Main Channel	2012	111	72	37	2	0	35	2
Main Channel	2011	60	31	23	5	1	48	10
Main Channel	2010	62	28	32	2	0	55	3
Main Channel	2009	137	106	30	1	0	23	1
Main Channel	2008	149	138	11	0	0	7	0
Main Channel	2007	29	24	5	0	0	17	0
Main Channel	2006*	NS	NS	NS	NS	NS	-	-
Main Channel	2005	60	37	20	2	1	38	5
Main Channel	2004	70	60	8	2	0	14	3
Main Channel	2003	52	27	23	2	0	48	4
Main Channel	2002	100	74	23	3	0	26	3
Main Channel	2001	90	71	16	3	0	21	3
Main Channel	2000	51	32	18	1	0	37	2

*not sampled due to high flows.

Termination Criteria Results

The Rush Creek sampling sections for years 2010 through 2014, failed to meet four of the five termination criteria for any of the three, three-year running averages.

The Upper Rush section met the density criterion for all three of the three-year running averages. For the most recent three-year running average (2012-2014) density was the only criteria met (Table 16).

Table 16. Termination criteria analyses for the Upper Rush section of Rush Creek. Bold values indicate that an estimated value met the termination criterion.

Termination Criteria	2012 – 2014 Average	2011 – 2013 Average	2010 – 2012 Average
Biomass (≥175 kg/ha)	162	**181**	**185**
Density (≥3,000 trout/km)	**6,322**	**8,408**	**8,281**
Condition Factor (≥1.00)	0.98	0.98	0.99
RSD-225 (≥35)	15	19	26
RSD-300 (≥5)	1	1	2
Conclusion	**Met one of five TC**	**Met two of five TC**	**Met two of five TC**

For the 2012-2014 three-year average, the Bottomlands section failed to meet any of the termination criteria (Table 17).

Table 17. Termination criteria analyses for the Bottomlands of Rush Creek. Bold values indicate that an estimated value met the termination criterion.

Termination Criteria	2012 – 2014 Average	2011 – 2013 Average	2010 – 2012 Average
Biomass (≥175 kg/ha)	70	83	103
Density (≥3,000 trout/km)	2,095	2,640	**3,115**
Condition Factor (≥1.00)	0.93	0.92	0.95
RSD-225 (≥35)	5	11	19
RSD-300 (≥5)	0	0	0
Conclusion	**Met none of five TC**	**Met none of five TC**	**Met one of five TC**

For the 2012-2014 three-year average, the MGORD failed to meet any of the RSD termination criteria. The MGORD RSD-375 average for 2012-2014 dropped to a value of 3 (Table 18).

Table 18. Termination criteria analyses for the MGORD section of Rush Creek. Bold values indicate that an estimated value met the termination criterion.

Termination Criteria	2012 – 2014 Average	2011 – 2013 Average	2010 – 2012 Average
RSD-225 (≥60)	57	**67**	**74**
RSD-300 (≥30)	17	24	26
RSD-375 (≥5)	3	4	4
Conclusion	**Met TC none of three RSD values**	**Met TC one of three RSD values**	**Met TC one of three RSD values**

For the 2012-2014 three-year average, the main and side channel of Lee Vining Creek together met the density criterion, but failed to meet the condition factor criterion for the first time (Table 19). The two channels combined also failed to meet the RSD-225 termination criterion for years 2011-2013 and 2012-2014 (Table 19).

Table 19. Termination criteria analyses for the Lee Vining Creek sample sections. Bold values indicate that an estimated value met the termination criterion.

Termination Criteria	2012 - 2014 Average	2011 - 2013 Average	2010 - 2012 Average
Biomass (≥150 kg/ha)	145	123	101
Density (≥1,400 trout/km)	**2,306**	**1,902**	1,143
Condition Factor (≥1.00)	0.95	**1.01**	**1.06**
RSD-225 (≥30)	17	26	**42**
Conclusion	**Met one of four TC**	**Met two of four TC**	**Met two of four TC**

PIT Tag Recaptures

PIT Tags Implanted between 2009 and 2014

In 2009, a total of 1,596 trout received PIT tags and adipose fin clips in Rush, Lee Vining, and Walker Creeks. Of the 1,596 trout tagged, 711 were age-0 and 861 were age-1+ brown trout, 19 were age-0 rainbow trout, and five were age-1 and older rainbow trout. In 2008, age-0 trout received adipose fin clips to help track growth rates of that cohort of trout into the future. Knowing that this cohort of trout was age-1 in 2009, 224 trout with adipose fin clips were PIT tagged in 2009. All trout in the MGORD were tagged; a total of 54 age-0 brown trout and 642 age-1 and older brown trout. No rainbow trout were captured in the MGORD. Most of these trout in the MGORD were older than age-1 (Table 20).

In 2010, a total of 1,274 trout received PIT tags and adipose fin clips in Rush, Lee Vining, and Walker Creeks. Of the 1,274 trout, 855 were age-0 and 43 were age-1 and older brown trout. Four age-0 and one age-1 and older rainbow trout received PIT tags and adipose fin clips. Again all trout in the MGORD (371 trout) were tagged and given an adipose fin clip. Of the 371 trout, 359 were age-1 and older brown trout and 12 were age-1 rainbow trout. Like 2009, most of the trout tagged in the MGORD were older than age-1 (Table 21).

In 2011, a total of 1,065 trout received adipose fin clips and PIT tags in Rush, Lee Vining, and Walker Creeks. Of these 1,065 trout, 851 were age-0 brown trout and 19 were age-1 and older brown trout. Fifty age-0 rainbow trout received PIT tags and adipose fin clips. All age-1 and older trout in the MGORD (145 trout) were tagged and given adipose fin clips. Of the 145 trout 142 were age-1 and older (mostly older) brown trout and three were age-1 and older rainbow trout (Table 22).

In 2012, a total of 496 trout received PIT tags and adipose fin clips in Rush, Lee Vining, and Walker Creeks. Of the 496 trout tagged, 412 were age-0 and 4 were age-1 and older brown trout. For rainbow trout, only age-0 fish were tagged in 2012 which totaled 80 trout. No new tags were implanted in trout in the County Road section, but trout with missing adipose fins and did not produce a tag number when scanned were retagged. No trout in the MGORD in 2012 were tagged or retagged due to a limited number of PIT tags available for deployment (Table 23).

In 2013, no PIT tags were implanted in any fish. Only length and weight data from recaptures of previously tagged fish were collected during the September 2013 sampling.

In 2014, a total of 964 trout received PIT tags and adipose fin clips in Rush, Lee Vining, and Walker Creeks. Of the 964 trout tagged, 459 were age-0 and 477 were age-1 and older brown trout. For rainbow trout, six age-0 fish were tagged and 22 age-1 and older fish were tagged. Because no PIT tags were deployed in 2013, suspected age-1 trout were tagged in 2014 and these fish were between 125 mm and 170 mm in length. Table 24 summarizes the tags implanted in September of 2014.

Table 20. Total numbers of trout implanted with PIT tags during the 2009 sampling season, by stream, sample section, age-class and species.

Stream	Sample Section	Number of Age-0 Brown Trout	Number of Age-1 Brown Trout	Number of Age-0 Rainbow Trout	Number of Age-1 Rainbow Trout	Reach Totals
Rush Creek	Upper Rush	256	26	15	1	**298 Trout**
	Bottomlands	164	68	0	0	**232 Trout**
	County Road	108	29	0	0	**137 Trout**
	MGORD	54	642*	0	0	**696 Trout**
Lee Vining Creek	Main Channel	10	45	4	3	**62 Trout**
	Side Channel	5	0	0	1	**6 Trout**
Walker Creek	Above old 395	114	51	0	0	**165 Trout**
Totals:		**711**	**861**	**19**	**5**	**Total Trout: 1,596**

*Many of these MGORD trout were >age-1.

Table 21. Total numbers of trout implanted with PIT tags during the 2010 sampling season, by stream, sample section, age-class and species.

Stream	Sample Section	Number of Age-0 Brown Trout (<125 mm)	Number of Age-1 and older Brown Trout	Number of Age-0 Rainbow Trout (<125 mm)	Number of Age-1 and older Rainbow Trout	Reach Totals
Rush Creek	Upper Rush	242	11	4	0	**257 Trout**
	Bottomlands	284	3	0	0	**287 Trout**
	County Road	210	7	0	0	**217 Trout**
	MGORD	1	359*	0	12	**372 Trout**
Lee Vining Creek	Main Channel	24	8	0	1	**33 Trout**
	Side Channel	13	0	0	0	**13 Trout**
Walker Creek	Above old 395	81	14	0	0	**95 Trout**
Totals:		**855**	**402**	**4**	**13**	**Total Trout: 1,274**

*Many of these MGORD trout were >age-1.

Table 22. Total numbers of trout implanted with PIT tags during the 2011 sampling season, by stream, sample section, age-class and species.

Stream	Sample Section	Number of Age-0 Brown Trout (<125 mm)	Number of Age-1 and older Brown Trout	Number of Age-0 Rainbow Trout (<125 mm)	Number of Age-1 and older Rainbow Trout	Reach Totals
Rush Creek	Upper Rush	393	3	30	0	**426 Trout**
	Bottomlands	178	1	11	0	**190 Trout**
	County Road	196	1	6	0	**203 Trout**
	MGORD	8	142*	3	3	**156 Trout**
Lee Vining Creek	Main Channel	24	0	0	0	**24 Trout**
	Side Channel	11	14	0	0	**25 Trout**
Walker Creek	Above old 395	41	0	0	0	**41 Trout**
Totals:		**851**	**161**	**50**	**3**	**Total Trout: 1,065**

*Many of these MGORD trout were >age-1.

Table 23. Total numbers of trout implanted with PIT tags during the 2012 sampling season, by stream, sample section, age-class and species.

Stream	Sample Section	Number of Age-0 Brown Trout (<125 mm)	Number of Age-1 and older Brown Trout	Number of Age-0 Rainbow Trout (<125 mm)	Number of Age-1 and older Rainbow Trout	Reach Totals
Rush Creek	Upper Rush	117	1	2	0	**120 Trout**
	Bottomlands	110	1	6	0	**117 Trout**
	County Road	0	2	0	0	**2 Trout**
	MGORD	0	0	0	0	**0 Trout**
Lee Vining Creek	Main Channel	125	0	72	0	**197 Trout**
	Side Channel	0	0	0	0	**0 Trout**
Walker Creek	Above old 395	60	0	0	0	**60 Trout**
Age Class Sub-totals:		**412**	**4**	**80**	**0**	**Total Trout: 496**

Table 24. Total numbers of trout implanted with PIT tags during the 2014 sampling season, by stream, sample section, age-class and species.

Stream	Sample Section	Number of Age-0 Brown Trout (<125 mm)	Number of Age-1 Brown Trout (125-170 mm)	Number of Age-0 Rainbow Trout (<125 mm)	Number of Age-1 Rainbow Trout (125-170 mm)	Section Totals
Rush Creek	Upper Rush	243	86	1	0	**330 Trout**
	Bottomlands	34	43	0	0	**77 Trout**
	MGORD	13	125-199 mm = 60 brown trout ≥200 mm = 185 brown trout			**258 Trout**
Lee Vining Creek	Main Channel	127	103	5	22	**257 Trout**
	Side Channel	0	0	0	0	**0 Trout**
Walker Creek	Above old 395	42	0	0	0	**42 Trout**
Age Class Sub-totals:		**459**	**232***	**6**	**22**	**Total Trout: 964**

*this sub-total excludes MGORD fish

In September of 2014, a total of 44 previously tagged trout were recaptured (Table 25). Most of the recaptures occurred in the MGORD section of Rush Creek (14 fish), followed by nine recaptures in both the main channel section of Lee Vining Creek and in Walker Creek (Table 25). Most fish were recaptured in the section where they were initially captured and PIT-tagged, except for two brown trout initially tagged in the MGORD. One fish was recaptured in the Upper Rush section and another fish was recaptured in the Bottomlands section of Rush Creek (Table 25).

In the following text, growth between 2013 and 2014 will be referred as a 2014 growth rate. A 2014 trout refers to a fish recaptured in September of 2014. An age of a PIT tagged trout reflects the age during the sampling year. For instance, an age-2 trout in 2014 indicates that a trout had been tagged in 2012 as age-0 and its length and weight were measured in 2014 when it was recaptured.

Because no PIT tags were deployed in September of 2013, no growth rates could be generated for age-1 trout between 2013 and 2014.

Table 25. PIT tagged trout recaptured in September 2014.

Date of Recapture	Species	Length (mm)	Weight (g)	PIT Tag Number	Location of 2014 Recapture	Location of Initial Capture and Tagging
9/6/2014	BNT	440	1040	985121017021569	Bottomlands	**MGORD**
9/6/2014	BNT	194	64	985121023622536	Bottomlands	Bottomlands
9/6/2014	BNT	219	93	985121023622964	Bottomlands	Bottomlands
9/6/2014	BNT	215	96	985121023645098	Bottomlands	Bottomlands
9/6/2014	BNT	215	89	985121023645973	Bottomlands	Bottomlands
9/6/2014	BNT	194	72	985121027924375	Bottomlands	Bottomlands
9/6/2014	BNT	192	67	985121028105663	Bottomlands	Bottomlands
9/9/2014	BNT	174	48	985121027900358	LV Main	LV Main
9/9/2014	**RBT**	229	124	985121028076573	LV Main	LV Main
9/9/2014	**RBT**	201	86	985121027913377	LV Main	LV Main
9/9/2014	BNT	195	75	985121028014990	LV Main	LV Main
9/9/2014	BNT	234	117	985121028058550	LV Main	LV Main
9/9/2014	BNT	195	72	985121028059034	LV Main	LV Main
9/16/2014	BNT	180	53	985121028072873	LV Main	LV Main
9/9/2014	BNT	241	128	985121028086331	LV Main	LV Main
9/16/2014	BNT	195	63	985121028117912	LV Main	LV Main
9/10/2014	BNT	242	107	985121023472600	LV Side	LV Side
9/8/2014	BNT	453	1043	985121004164176	MGORD	MGORD
9/8/2014	BNT	375	550	985121017022012	MGORD	MGORD
9/8/2014	BNT	426	644	985121020904177	MGORD	MGORD
9/15/2014	BNT	570	1739	985121020917818	MGORD	MGORD
9/15/2014	BNT	398	532	985121021876593	MGORD	MGORD
9/8/2014	BNT	459	728	985121021900392	MGORD	MGORD
9/15/2014	BNT	490	1289	985121021902500	MGORD	MGORD
9/15/2014	BNT	299	250	985121021902621	MGORD	MGORD
9/8/2014	BNT	339	331	985121021913730	MGORD	MGORD
9/15/2014	BNT	354	525	985121021914561	MGORD	MGORD
9/15/2014	BNT	410	581	985121023369646	MGORD	MGORD
9/8/2014	BNT	502	1378	985121023444595	MGORD	MGORD
9/15/2014	BNT	360	416	985121023446237	MGORD	MGORD
9/15/2014	BNT	360	461	985121023446780	MGORD	MGORD
9/12/2014	BNT	288	231	985121020917694	Upper Rush	Upper Rush
9/5/2014	BNT	226	121	985121021871564	Upper Rush	Upper Rush
9/12/2014	BNT	370	509	985121021900424	Upper Rush	**MGORD**
9/12/2014	BNT	236	134	985121027927325	Upper Rush	Upper Rush

Table 25 (continued). PIT tagged trout recaptured in September 2014.

Date of Recapture	Species	Length (mm)	Weight (g)	PIT Tag Number	Location of 2014 Recapture	Location of Initial Capture and Tagging
9/10/2014	BNT	211	94	985121020122109	Walker	Walker
9/10/2014	BNT	220	87	985121020929212	Walker	Walker
9/10/2014	BNT	221	107	985121021865724	Walker	Walker
9/10/2014	BNT	168	47	985121021870087	Walker	Walker
9/10/2014	BNT	194	68	985121021886870	Walker	Walker
9/10/2014	BNT	222	123	985121023448952	Walker	Walker
9/10/2014	BNT	180	55	985121023457153	Walker	Walker
9/10/2014	BNT	207	97	985121023467904	Walker	Walker
9/10/2014	BNT	200	83	985121023470718	Walker	Walker

Growth of Age-2 Brown Trout between 2013 and 2014

In 2014, a total of 10 known age-2 brown trout were recaptured that were tagged as age-0 fish in 2012, for a recapture rate of 2.4% (10/412 age-0 fish tagged in 2012). No age-2 brown trout that were tagged in 2012 were recaptured in the Upper Rush section in 2014, thus we were unable to calculate growth rates between age-1 to age-2 (Table 26).

In the Bottomlands section of Rush Creek one age-2 fish was recaptured in 2014 and had a growth rate of 32 mm and 29 grams (Table 26). Compared to 2013 rates, the growth rate of the one 2014 age-2 brown trout was greater by 5 mm and 7 g (Table 26). Growth rates of age-2 brown trout in the Bottomlands section have generally declined annually since 2010 (Table 26).

The Lee Vining Creek main channel had five age-2 PIT tagged brown trout recaptured in 2014. The average growth rates of these trout were 35 mm and 29 g (Table 26). When compared to the 2013 growth rates of age-2 fish, the 2014 growth rates increased by 6% for length and decreased by 15% for weight (Table 26).

Walker Creek had four age-2 PIT tagged brown trout recaptured in 2014. Average growth rates of these fish were 39 mm and 35 g (Table 26). When compared to the 2013 growth rates of age-2 fish, the 2014 growth rates increased by 44% for length and 67% for weight (Table 26).

Growth of Age-2 Rainbow Trout in Lee Vining Creek between 2013 and 2014

In 2014, a total of two known age-2 rainbow trout were recaptured in Lee Vining Creek that were tagged as age-0 fish in 2012, for a recapture rate of 2.8% (2/72 age-0 fish tagged in 2012). Average growth rates of these two fish were 40 mm and 48 g (Table 26). Previously, no age-2 rainbow trout with PIT tags had been recaptured, thus no comparisons with the 2014 growth rates were feasible.

Table 26. Average growth (length and weight) of all brown trout recaptured from 2009 through 2014 by age. Note: *denotes only one fish recaptured.

Stream and Reach	Cohort	Average Annual Growth Length (mm)						Average Annual Growth Weight (g)					
		2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014
Upper Rush Creek	Age 1	89	81	83	72	67		51	50	48	33	35	
	Age 2		58	54	43	41			70	73	42	42	
	Age 3				14		24				29		41
	Age 4					12						-22	
	Age-5												
Rush Creek Bottom-lands	Age 1	84	77	71	58	56		43	40	35	25	24	
	Age 2		50	35	30	27	32*		54	32	28	22	29*
	Age 3			13	17	11	35			14	16	9	31
	Age 4				4						-11		
	Age-5												
Lee Vining Main Channel	Age 1		80*	72	99	61			42*	37	52	27	
	Age 2		66		77	33	35		95		110	34	29
	Age 3			34		23*	16*			92		48*	20*
	Age 4				21*						41*		
	Age-5												
LV Main Channel Rainbow Trout	Age 1					78						47	
	Age 2						40						48
	Age 3												
	Age 4												
	Age-5												
Walker Creek Above Old 395	Age 1	68	51	71	68	59		27	20	34	36	23	
	Age 2		31	60	40	27	39		26	56	33	21	35
	Age 3			28	18	9	20			44	12	2	36
	Age 4				7	2*					2	-16*	
	Age-5						0						-10

Growth of Age-3 Brown Trout between 2013 and 2014

In 2014, a total of eight known age-3 brown trout were recaptured that were tagged as age-0 fish in 2011, for a recapture rate of 0.9% (8/851 age-0 fish tagged in 2011). The one-year growth of trout between age-2 and age-3 was typically less than the one-year growth rates of younger fish.

In the Upper Rush section, two PIT tagged age-3 brown trout were recaptured during the 2014 sampling that had also been recaptured as age-2 fish in 2013. These two fish had average growth rates of 24 mm and 41 g (Table 26); however one fish lost 1 mm and gained 19 g and the other fish gained 48 mm and 62 g.

In the Bottomlands section, two PIT tagged age-3 brown trout were recaptured during the 2014 sampling that had also been caught as age-2 fish in 2013. These two brown trout had average growth rates of 35 mm and 31 g (Table 26). Compared to 2013 growth rates, the growth rates of age-3 brown trout increased by 24 mm and 22 g in 2014 (Table 26).

In the Lee Vining Creek main channel a single PIT tagged age-3 brown trout was recaptured in 2014. Its one-year growth between 2013 and 2014 was 16 mm and 20 g (Table 26). In 2013, a single age-3 brown was recaptured and exhibited more than twice the growth rate, in weight, of the 2014 fish (48 g versus 20 g) (Table 26).

In Walker Creek three PIT tagged age-3 brown trout were recaptured in 2014 and these three fish have been recaptured each year since being tagged at age-0 in 2011. These three trout had average growth rates of 20 mm and 36 g. Compared to 2013 rates, the growth rates of age-3 brown trout increased by 122% for length and 1,700% for weight in 2014 (Table 26). The 2014 growth rates of age-3 brown trout in Walker Creek were the highest since 2011 (Table 26).

Growth of Age-4 and Age-5 Brown Trout between 2013 and 2014

No PIT tagged age-4 brown trout were recaptured in 2014 that were also recaptured in 2013 as age-3 fish, thus no growth rates of age-4 fish were available. An age-4 brown trout was captured in Upper Rush, but this was its first recapture since being PIT tagged at age-0 in 2010. This age-4 fish was 288 mm in length and weighed 231 g.

In Walker Creek, a single age-5 brown trout was recaptured and between 2013 and 2014 this fish’s length remained the same (220 mm) and it lost 10 g in weight (Table 26). This fish was also recaptured in 2012 and 2013 and between these years it gained 4 mm in length, but lost 5 g in weight.

Average Growth Rate of Rainbow Trout

In 2014, two age-2 PIT tagged rainbow trout were recaptured in the main channel section that had also been recaptured as age-1 fish in 2013. These age-2 fish had average growth rates of 40 mm in length and 48 g in weight (Table 26).

Growth of MGORD Brown Trout by size class between 2013 and 2014

Because there were no recaptures of known aged brown trout in the MGORD, determination of actual ages of recaptured trout was not possible. Thus, growth rate comparisons within the MGORD were based on size classes (Table 27). Due to the majority of the brown trout in the MGORD being larger sized, size classes were based on the RSD values for the MGORD. When evaluating growth rates by size classes, the size classes in Table 27 designate each fish's size class in 2013, not its size class at the time of recapture in 2014.

In 2014, a total of 14 PIT tagged brown trout were recaptured in the MGORD that were originally PIT tagged in the MGORD. Of these 14 recaptures, five fish had also been captured in 2013, thus one-year growth rates between 2013 and 2014 were calculated for these fish.

No PIT tagged brown trout captured in the MGORD in 2013 within the 226-300 mm size class were recaptured in 2014.

There was one PIT tagged brown trout captured in the MGORD in 2013 within the 301-375 mm size class that was recaptured in 2014. This trout grew 30 mm in length and gained 178 g in weight (Table 27).

There were four PIT tagged brown trout captured in the MGORD in 2013 within the >375 mm size class that were recaptured in 2014. These four trout had average growth rates of 17 mm and 283 g between 2013 and 2014 (Table 27). Of the four fish, one lost weight (-157 g) and the three remaining fish experienced weight gains of 552, 327 and 128 g.

Table 27. Average growth rates, length (mm) and weight (g), of all brown trout recaptured from 2009 through 2013 by size class. Note: *denotes only one fish recaptured.

Size Class (mm)	**Average Annual Growth Length (mm)**					**Average Annual Growth Weight (g)**				
	2009-2010	**2010-2011**	**2011-2012**	**2012-2013**	**2013-2014**	**2009-2010**	**2010-2011**	**2011-2012**	**2012-2013**	**2013-2014**
0-124	121					91				
125-225	55	59	63			85	90	78		
226-300	32	39	22	7		53	81	34	2	
301-375	20	17	9	12	30*	23	54	**-5**	49	178*
>375	13	18	**-1**	10	17	**-10**	134	**-47**	**-2**	283

Growth of MGORD Brown Trout from non-consecutive years

Nine of the 14 PIT tagged brown trout captured in the MGORD during the 2014 sampling were captured, measured and weighed in years prior to 2013; thus annual growth calculations were not possible. These nine brown trout exhibited a wide range growth, from a fish tagged in 2011 that grew 12 mm in length and gained 1 g in three years (#1913730) to a fish tagged in 2009 that grew 159 mm and gained 771 g in four years (#4164176) (Table 28).

Table 28. PIT tagged brown trout caught in the MGORD section, nonconsecutive recaptures.

Last 7 Digits of PIT Tag #	Year of Capture	Total Length (mm)	Weight (g)	Difference in Length (mm)	Difference in Weight (g)
4164176	2009	294	272		
	2014	453	1043	+159	+771
7022012	2009	293	266		
	2014	375	550	+82	+284
1876593	2010	321	331		
	2014	398	532	+77	+201
1900392	2010	360	383		
	2014	459	728	+99	+345
1902621	2011	258	163		
	2012	282	205		
	2014	299	250	+17	+45
1913730	2011	317	330		
	2012	331	321		
	2014	339	331	+8	+10
1914561	2010	268	209		
	2012	320	323		
	2014	354	525	+34	+202
3369646	2010	330	329		
	2011	362	437		
	2014	410	581	+48	+144
3446237	2011	297	235		
	2012	324	275		
	2014	360	416	+36	+141

Movement of PIT Tagged Trout between Sections

From 2009 to 2014 a total of 5,395 PIT tags were surgically implanted in brown and rainbow trout in the following stream reaches: Upper Rush, County Road, Bottomlands, MGORD, and Walker Creek. Between 2010 and 2014, 27 brown trout have been recaptured in a stream reach other than where they were initially tagged. The majority of movement between sections has occurred from the Upper Rush section upstream into the MGORD, and from the MGORD downstream into the Upper Rush section. There has also been some movement between the Bottomlands and County Road sections. Up to 2013, no other movement between sections had been recorded.

The 2012 Annual Fisheries Report presented the summarized data for 23 brown trout that had moved from one section to another. In all cases, fish which moved experienced higher growth rates than other members of their cohorts which stayed in the section where they had been tagged (LADWP 2013). These growth differences were most markedly different for brown trout PIT tagged as age-0 fish in the Upper Rush section that were eventually recaptured in the MGORD as age-1 or age-2 fish.

In 2014, two brown trout tagged in the MGORD were recaptured in other sections of Rush Creek (Table 25). Fish #1900424 was tagged in 2011 at 344 mm/400 g, was recaptured in the MGORD in 2012, was still 344 mm long, but had lost 80 g. Two years later (2014) this fish was caught in Upper Rush as a 370 mm/509 g fish. The second fish recaptured in 2014 that had moved out of the MGORD was #17021569 (tagged in 2009 as a 274 mm/210 g fish). This fish was recaptured in 2013 in the MGORD as a 410 mm/670 g fish. In 2014, this fish was recaptured again in the Bottomlands section as a 440 mm/1040 g fish. Within a one-year period, this fish migrated approximately six miles downstream and grew 30 mm in length and gained 370 g (Figure 24). Between the three-year radio telemetry study and five years of PIT tag recaptures, fish #17021569 was the first fish we have documented moving through the Narrows. During the radio telemetry study, a large male brown trout from the MGORD was relocated near the mouth of Walker Creek, but never moved downstream past the Narrows (Taylor et al. 2009).

Shed Rate of PIT Tags between 2009 and 2013

In 2014, a total of three trout with adipose fin clips were recaptured and failed to produce a PIT tag number when scanned with the tag reader. Assuming that these three trout in 2014, the 12 trout in 2013, the 13 fish in 2012, the eight trout in 2011, and the 45 trout in 2010 were all previously PIT tagged, the calculated shed rate was 1.5% (81 shed tags/5,395 tags deployed). This rate was lower than rates reported by other PIT tagging studies (Ombredane et al. 1998; Bateman and Gresswell 2006 as cited in Taylor and Knudson. 2011).

Figure 24. Brown trout with PIT tag #17021569 recaptured in the Bottomlands section in 2014.

Comparison of Length-at Age amongst Sample Sections

During 2014, four age-classes of PIT tagged brown trout were recaptured within four fisheries monitoring sections in Rush, Walker and Lee Vining creeks (Table 29). Along with providing age-specific length information for each section, these data also allowed comparisons of length-at-age between sample sections and also between the years 2013 and 2014 (Table 29).

In the Bottomlands section, a single age-2 brown trout was recaptured in 2014 that was 192 mm in length, near the upper range of age-2 fish caught in 2013 (Table 29). No age-2 fish were recaptured in Upper Rush in 2014 and no comparisons of length-at-age were made between the sections.

At age-3, brown trout from the Bottomlands section were much smaller than age-3 trout from the Upper Rush section (Table 29). The largest Bottomlands fish was equal in length (227 mm) to the smallest age-3 fish from Upper Rush and the average lengths were 39 mm apart (Table 29). This discrepancy in length-at-age increases between the two sections for age-4 brown trout, with Upper Rush age-4 fish 72 mm longer than age-4 Bottomlands fish (Table 29).

In the main channel of Lee Vining Creek age-2 and age-3 brown trout in 2014 were on average, smaller than similar age fish in 2013, 27 mm difference at age-2 and 15 mm difference at age-3 (Table 29). No PIT tagged brown trout greater than age-3 were captured in Lee Vining Creek in 2013 and 2014, thus no comparisons of length-at-age-3 were possible.

In 2014, age-2 and age-3 brown trout in Walker Creek were, on average, larger than the same cohorts in the Bottomlands section of Rush Creek, but smaller than the same cohorts in Upper

Rush (Table 29). Two PIT tag recoveries from Walker Creek in 2014 indicate that growth of older fish slows considerably at age-4 and age-5 (Table 29).

These findings of average lengths by age-class appear to support the previous conclusions by the Stream Scientist that very few brown trout reach age-4 or older on Rush Creek or Lee Vining Creek. Also, the low growth rates that brown trout exhibited in Rush Creek during dry runoff years make it highly unlikely that many fish survive long enough to attain lengths ≥300 mm.

Table 29. Size range of PIT tagged fish recaptured in 2014 by age class for brown trout at three electrofishing sections on Rush and Walker Creeks and for brown trout and rainbow trout on Lee Vining Creek. NOTE*:* when available, values from 2013 in ( ) for comparison.

Section	Cohort	Size Range (mm)	Average Length (mm)
Upper Rush	Age-1	None available for capture	
	Age-2	None captured	
	Age-3	226-236 (227-263)	231 (245)
	Age-4	288 (252-255)	288 (254)
	Age-5	298	298
Bottomlands	Age-1	None available for capture	
	Age-2	192 (156-196)	192 (178)
	Age-3	194 (194-227)	194 (204)
	Age-4	215-219 (none in 2013)	216
	Age-5	None captured	
Walker Creek	Age-1	None available for capture	
	Age-2	168-200 (181-208)	186 (197)
	Age-3	207-222 (219-221)	217 (220)
	Age-4	211 (219)	211 (219)
	Age-5	220	220
Brown Trout in Lee Vining Main Channel	Age-1	None available for capture	
	Age-2	174-195 (206-225)	188 (215)
	Age-3	234-241 (238-271)	238 (253)
	Age-4	None captured	
	Age-5	None captured	
Rainbow Trout in Lee Vining Main Channel	Age-1	None available for capture	
	Age-2	201-229	215
	Age-3	None available for capture	
	Age-4	None available for capture	
	Age-5	None captured	

Discussion

The 2014 sampling year was the sixteenth consecutive year in which fish population data were collected and the sixth year since PIT tagging was initiated on Rush, Lee Vining, and Walker creeks. The fish sampling methods have been consistent since they were derived from two years of pilot studies conducted in 1997 and 1998. The 2014 runoff year was 48% of normal and classified as a dry runoff year type. This was the third consecutive dry runoff year type (RY 2013 was 66% of normal and RY 2012 was 55% of normal).

Calendar year 2014 was also marked by LADWP, the Mono Lake Committee, California Trout, and the California Department of Fish and Wildlife continuing to translate the new settlement terms (signed in September 2013) into enforceable license language prior to issuance of amended licenses by the State Water Resources Control Board. Major components of the Terms of Settlement include: 1) release of SEF flow regimes, 2) modification of GLR Dam by LADWP to permit release of SEF wet-year peak flows, 3) export of additional water to offset capital costs of the GLR Dam project, 4) deference of mandated SWRCB hearing on Mono Lake levels until 2020, and 5) development of a Mono Basin Monitoring Administrative Team to oversee a 10-year post-settlement monitoring program funded annually by LADWP.

The 2013 Annual Fisheries Report's Discussion section focused on the 2013 summer thermal regime in Rush Creek and its potential effects on trout growth, condition factor and survival. Because 2014 was marked by another dry year and likely adverse thermal conditions for growth, this report's Discussion will focus on similar analyses.

Brown Trout Responses to three Consecutive Dry Runoff Years

As previously stated, RYs 2012, 2013, and 2014 were consecutive dry year-types. During the summer of 2014, the water level in GLR was consistently lower than in 2013 which, in turn, had consistently lower water levels than in 2012 (Figure 4). The preliminary summary of 92 days of water temperature data in Rush Creek between July 1 and September 30, 2014 indicated periods where temperatures were not favorable for trout growth and that the unfavorable conditions in 2014 exceeded those documented 2013 (Table 1). Before discussing the fish growth and condition factor results, further examination of the water temperature data is warranted.

The SNTEMP temperature modeling conducted for development of Synthesis Report recommendations examined past summer water temperature data sets to determine a range of average daily temperatures that would be indicative of good growth conditions for brown trout and a threshold above which would be classified as a "bad thermal day" for brown trout (Appendix D-4.4 of Synthesis Report). The basis of these analyses was a study that measured the growth of brown trout provided varying food rations over a range of water temperatures (Elliot and Hurley 1999). A figure from this study depicted how growth rates gradually improved as temperatures increased to about 57^{o}F and then growth rates rapidly dropped as temperatures increased beyond 57^{o}F (Figure 25). For the Rush Creek SNTEMP model calibration we then overlaid the temperature range cited by other authors as providing good growth opportunities (Raleigh et al. 1996; Ojanguren et al. 2001). Interestingly, the "good" growth up to 67^{o}F cited by these authors is not reflected in caloric gain measured by Elliot and Hurley (1999), especially when less than 100% rations were provided (Figure 25). Also, a literature review by Bell (2006) regarding the thermal impacts on growth, reproduction, and survival of brown trout concluded that:

> "Studies tend to agree that the stream distribution of healthy adult brown trout is largely bounded by the 19^{o}C thermal physiological limit, with a maximum not to exceed 22^{o}C for an extended period. In this thermal window of 19-22^{o}C (**66.2-71.6^{o}F**), brown trout may be physiologically stressed and living at the edge of their survival tolerance. Furthermore, temperatures of 19-22^{o}C are near the upper metabolic limit of trout and may affect their ability to gain weight or maintain normal physiological functions. Brown trout do not grow in the 19-22^{o}C range and are likely to experience high mortality rates from both the direct and indirect effects of inhabiting this temperature range. Reproductive efforts may also be limited by depressed juvenile fitness following a reduction in female condition prior to spawning".

Research by Vornanen et al. (2012) appears to support the Bell (2006) conclusion. Their research determined that the impairment of brown trout cardiac function started at 20.6^{o}C and rapidly deteriorated as temperatures were increased (Vornanen et al. 2012).

Our analyses for the SNTEMP modeling examined thousands of records of summer water temperature data from Rush Creek and determined that daily average water temperatures between 55.5^{o}F and 60.5^{o}F defined the range of "good growth" for brown, and potential for growth would likely decline rapidly as daily averages increased above 60.5^{o}F. When daily average water temperatures exceeded 65^{o}F, these days were defined as "bad thermal" days because these days often had extended periods where temperatures exceeded 67^{o}F.

Another temperature metric to consider is diurnal fluctuation. Needham (1969) concluded that both absolute temperature and thermal constancy determined habitat suitability, and that trout in streams with springs and relatively constant temperatures experienced high growth rates. Werley et al. (2007) found that the maximum temperature fluctuations tolerated by brown trout varied as a function of daily mean temperature and length of exposure. For example, the maximum tolerated temperature fluctuations were 11.5^{o}F for a 63-day exposure and 12.6^{o}F for a 21-day exposure. Chadwick (2012) reported that brook trout exposed to 14^{o}F diurnal fluctuations exhibited significantly reduced growth rates (43% by length and 35% by weight). The Werhly et al. (2007) study determined that the upper thermal tolerance limits of brown trout and brook trout were similar, thus the mention of the Chadwick (2012) brook trout research. Finally, Werhly et al. (2007) concluded that chronic temperature effects in concert with fluctuations play an important role in limiting salmonid distributions.

Similar to last year's report, a closer examination of the 2014 Rush Creek summer water temperature data was done by classifying daily average temperatures as either: 1) good growth potential days, 2) fair growth days (daily averages on sharply declining limb of Figure 26, 3) poor potential growth days (daily averages within one degree or less of a "bad thermal day"), or 4) bad thermal days (Table 30). Using these daily average metrics, good growth potential days in 2014 varied from five to 17 days in Rush Creek out of the 92-day period from July 1 to

September 30. Nearly all of these “good” days occurred in mid to late September. The days designated as “fair” occurred primarily in July and September. The “poor” days and “bad” thermal days were mostly clustered in late-July through most of August. Compared to 2013, in 2014 there was a consistent shift towards more “poor” and “bad” thermal days; and this shift was most pronounced at the three uppermost water temperature recording locations (Table 30). For example, at the top of the MGORD there were 35 “poor” and “bad” thermal days in 2013, compared to 73 “poor” and “bad” thermal days in 2014 (Table 30). Consistently lower storage levels in GLR during the summer 2014 most likely influenced this shift in thermal days.

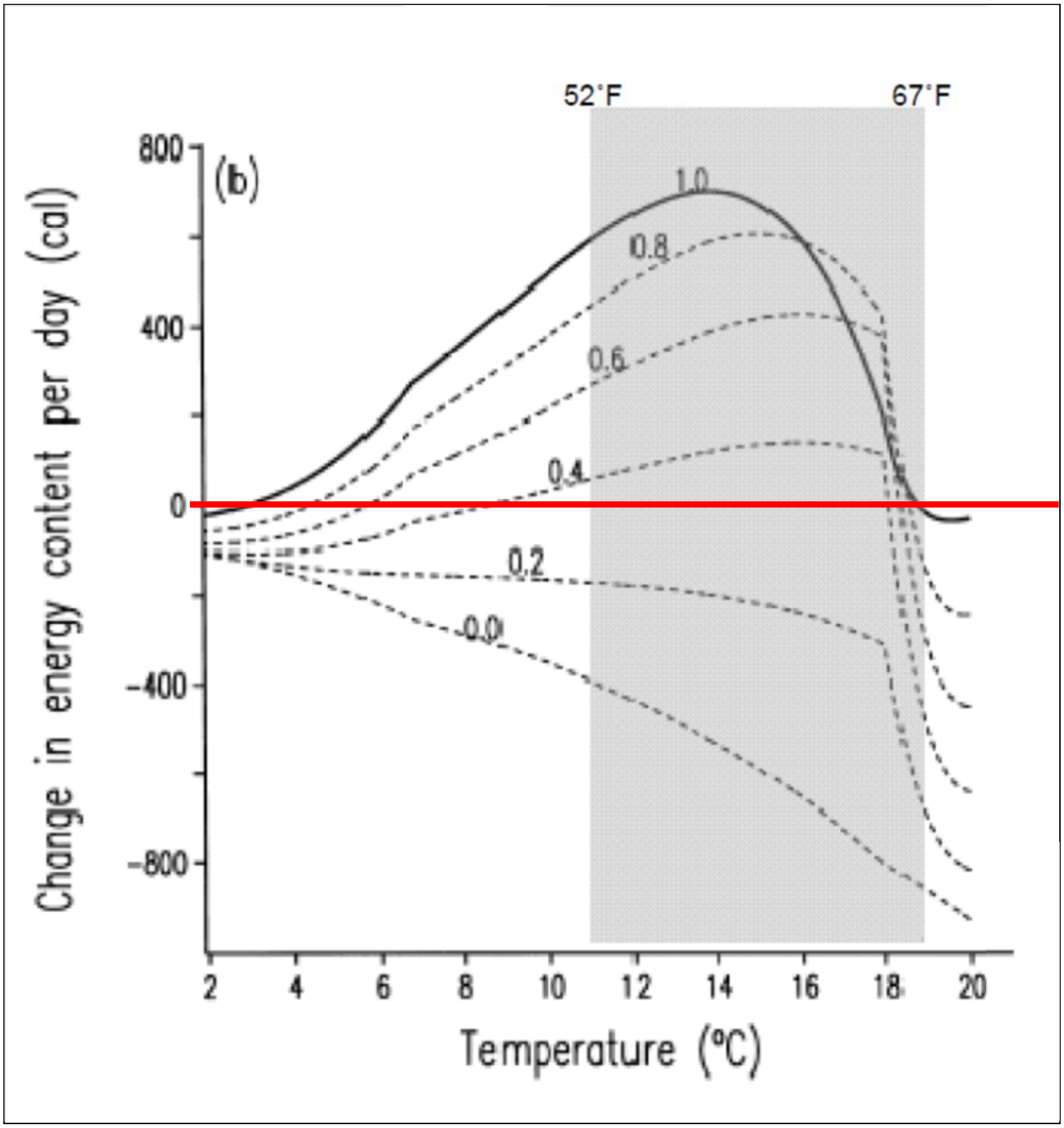


Figure 25. Relationship between water temperature and growth (expressed in change in energy content per day in calories) with numbers showing proportion of full ration provided to fish (graph from Elliot and Hurley 1999). Shaded portion of graph is temperature range cited as “good growth temperature” by Raleigh et al. 1996 and Ojanguren et al. 2001. NOTE: red line was added to enhance “no change in energy content” demarcation on the y-axis.

Table 30. Classification of runoff year 2013 and 2014 water temperature data into good growth days, fair growth, poor growth days and bad thermal days based on daily average temperatures (92-day period from July 1 to September 30). The percent (%) designates each thermal day-type's occurrence for the 92-day summer period.

Temperature Monitoring Location	**No. of Days for Good Growth Potential – Daily Ave. 55.5° - 60.5°F**	**No. of Days for Fair Growth Potential – Daily Ave. 60.6° – 63.9°F**	**No. of Days of Poor Growth Potential – Daily Ave. 64.0° - 64.9°F**	**No. of Bad Thermal Days - Daily Ave. ≥65°F**
Rush Ck. – Top of MGORD	2013 = 14 (15%) 2014 = 5 (6%)	2013 = 43 (47%) 2014 = 14 (15%)	2013 = 17 (18%) 2014 = 25 (27%)	2013 = 18 (20%) 2014 = 48 (52%)
Rush Ck. – Bottom MGORD	2013 = 11 (12%) 2014 = 6 (6%)	2013 = 38 (41%) 2014 = 11 (12%)	2013 = 20 (22%) 2014 = 21 (23%)	2013 = 23 (25%) 2014 = 54 (59%)
Rush Ck. – Old Highway 395	2013 = 14 (15%) 2014 = 7 (8%)	2013 = 41 (45%) 2014 = 25 (27%)	2013 = 33 (36%) 2014 = 27 (29%)	2013 = 4 (4%) 2014 = 33 (36%)
Rush Ck. – below Narrows	2013 = 17 (18%) 2014 = 13 (14%)	2013 = 69 (75%) 2014 = 58 (63%)	2013 = 6 (7%) 2014 = 18 (20%)	2013 = 0 2014 = 3 (3%)
Rush Ck. – County Road	2013 = 17 (18%) 2014 = 17 (18%)	2013 = 64 (70%) 2014 = 59 (65%)	2013 = 8 (9%) 2014 = 14 (15%)	2013 = 3 (3%) 2014 = 2 (2%)

Consistent with last year's analysis, in 2014 the Bottomlands section where brown trout exhibited the lowest growth rates and poor condition factors had fewer "poor" and "bad" thermal days (County Road temperature monitoring location) compared to the upstream temperature monitoring locations. While brown trout in the Upper Rush section experienced reduced growth rates and condition factors compared to previous years, these trout's growth and condition factor metrics still out-performed the Bottomlands in 2014. Initially counterintuitive, these results suggest that additional factors beyond daily average water temperatures influenced brown trout growth and condition factor in Rush Creek, most likely the effects of widely variable diurnal temperature fluctuations.

As was done with the 2013 data, the diurnal temperature fluctuations for July–September 2014 were characterized by the one-day maximum fluctuation that occurred each month and by monthly averages (Table 31). Also, for each temperature monitoring location, the highest average diurnal fluctuation over consecutive 21-day duration was determined (Table 31). Similar to the 2013 analysis, the 2014 data consistently show worse metrics at the Below Narrows and County Road temperature monitoring locations when compared to the upper three locations. For all months, the one-day maximum and monthly average fluctuations were greatest at the Below Narrows and County Road locations (Table 31). The 21-day duration values for the Below Narrows and County Road locations exceeded the 12.6°F tolerance limit defined by Werley et al. (2007). When compared to the 2013 diurnal fluctuations, the 2014 fluctuation were less severe at Top of MGORD, Bottom of MGORD and Old 395 temperature monitoring locations; however the 2014 fluctuations were more severe at Below Narrows and County Road monitoring locations (Table 31).

Table 31. Diurnal temperature fluctuations in Rush Creek for 2014: maximum daily for month, daily average for month, and highest average for consecutive 21-day duration (92-day period from July 1 to September 30). NOTE: 2013 values in ( ) for comparison.

Temperature Monitoring Location	Maximum and Average Daily Diurnal Fluctuation for July	Maximum and Average Daily Diurnal Fluctuation for August	Maximum and Average Daily Diurnal Fluctuation for September	Highest Average Diurnal Fluctuation for a Consecutive 21-Day Duration
Rush Ck. – Top of MGORD	Max = 3.9°F (4.2) Ave = 0.9°F (1.8)	Max = 1.0°F (1.5) Ave = 0.3°F (0.9)	Max = 1.3°F (1.4) Ave = 0.5°F (0.6)	1.1°F (2.0) July 1-21
Rush Ck. – Bottom MGORD	Max = 8.3°F (9.0) Ave = 6.1°F (6.8)	Max = 6.8°F (7.5) Ave = 5.4°F (6.2)	Max = 6.8°F (7.1) Ave = 5.4°F (5.6)	6.4°F (7.0) July 1-21
Rush Ck. – Old Highway 395	Max = 13.4°F (13.5) Ave = 10.1°F (10.4)	Max = 12.0°F (12.6) Ave = 9.4°F (10.4)	Max = 11.5°F (10.7) Ave = 8.7°F (8.8)	10.4°F (11.3) July 1-21
Rush Ck. – below Narrows	Max = 17.3°F (16.3) Ave = 12.7°F (11.7)	Max = 16.1°F (15.0) Ave = 12.5°F (12.4)	Max = 15.2°F (12.6) Ave = 11.8°F (10.2)	14.1°F (13.2) Aug 14 – Sept 3
Rush Ck. – County Road	Max = 17.6°F (14.1) Ave = 10.1°F (10.0)	Max = 15.6°F (14.7) Ave = 12.2°F (11.3)	Max = 15.4°F (11.6) Ave = 11.5°F (9.2)	13.9°F (12.5) Aug 14 – Sept 3

The thermal window bounded by 66.2-71.6°F where brown trout may be physiologically stressed and living at the edge of their survival tolerance was quantified for each Rush Creek temperature monitoring location. The hourly temperature data for the 92-day (or 2,208-hour) summer period were sorted from low to high and the number of hours where temperatures exceeded 66.2°F were summed by month and entire summer period (Table 32). The values from 2013 were also included in Table 32 to better illustrate the increases which that occurred in 2014 at all the temperature monitoring locations. Between 2013 and 2014, the largest increase in the number of hourly temperatures ≥66.2 °F occurred at the Top of the MGORD location during July (Table 32). Again, this initial input of warm water at the upstream end of the MGORD translated into increased temperatures throughout lower Rush Creek during the summer of 2014 (Table 32). The 2014 data show that all the temperature monitoring locations were within the 66.2-71.6°F thermal window for 19% to 29% of the 92-day summer period. At all monitoring locations, the month of July had the highest percentage of hours within the thermal window during the summer of 2014 (Table 32). As with the 2013 data, the 2014 data also illustrates a sizeable warming trend as streamflow travels down the MGORD (Table 32).

Finally, water temperature data collected from the “At Dam Site” location in Rush Creek upstream of GLR quantified the thermal loading of water that passed through GLR prior to release into the upstream end of the MGORD (Table 33). For the month of July, the average temperature was 5.2°F cooler in Rush Creek upstream of GLR than at the top of the MGORD (Table 33). The greatest difference in average water temperatures occurred in August, with Rush Creek above GLR 6.7°F cooler than at the top of the MGORD (Table 33). In September, the difference in average water temperatures was 4.9°F (Table 33). During the summer of 2014, GLR's storage elevation was several feet above the "*low*" GLR level as defined in the Synthesis Report by the Stream Scientists as a level where warm water temperatures should be a concern (<20,000 AF storage or 7,100 ft elevation) (Figure 4). Regardless, water travelling through GLR heated-up, had minimal diurnal fluctuation, and entered the top of the MGORD warm enough to create unfavorable thermal conditions for brown trout for most of the summer. Although Rush Creek's thermal regime was most likely going to be poor during the summer of 2014 due to the lack of snowpack and three consecutive dry-years, the timing of LADWP's exports may have exacerbated the situation. Between April 3rd and May 24th, GLR's storage level dropped 14 feet (from 7,112 to 7,098 feet) as LADWP exported their allotted 16,000AF (Figure 4). In future dry-year scenarios with relatively low reservoir storage, it may be prudent for LADWP to consider delaying their exports until later in the year, allowing GLR to gain storage of cooler runoff in the late-spring/early-summer. This approach would most likely delay the start of thermally stressful conditions for brown trout in Rush Creek downstream of GLR; however trade-offs to consider (that are beyond the scope of this report) include potential thermal impacts to the Owens River trout fishery.

Table 32. Number of hours that temperature exceeded 66.2°F in Rush Creek: by month and for 92-day period from July 1 to September 30, 2013 and 2014. Percent (%) designates amount of month or summer where hourly temperatures exceeded 66.2°F.

Temperature Monitoring Location	Number of Hours Temperature exceeded 66.2°F in July (744 hours)	Number of Hours Temperature exceeded 66.2°F in August (744 hours)	Number of Hours Temperature exceeded 66.2°F in Sept. (720 hours)	Number of Hours Temperature exceeded 66.2°F in 92-day period
Rush Ck. – Top of MGORD	2013 = 4 hrs (0.5%) 2014 = 315hrs (42%)	2013 = 4 hrs (0.5%) 2014 = 96 hrs (13%)	2013 = 0 hrs 2014 = 0 hrs	2013 = 8 hrs (0.4%) 2014 = 411 hrs (19%)
Rush Ck. – Bottom MGORD	2013 = 121 hrs (16%) 2014 = 282 hrs (38%)	2013 = 229 hrs (31%) 2014 = 248 hrs (33%)	2013 = 61 hrs (9%) 2013 = 115 hrs (16%)	2013 = 411 hrs (19%) 2014 = 645 hrs (29%)
Rush Ck. – Old Highway 395	2013 = 181 hrs (24%) 2014 = 287 hrs (39%)	2013 = 228 hrs (31%) 2014 = 248 hrs (33%)	2013 = 73 hrs (10%) 2014 = 117 hrs (16%)	2013 = 482 hrs (22%) 2013 = 639 hrs (29%)
Rush Ck. – below Narrows	2013 = 158 hrs (21%) 2014 = 244 hrs (33%)	2013 = 192 hrs (26%) 2014 = 193 hrs (26%)	2013 = 55 hrs (7%) 2014 = 105 hrs (15%)	2013 = 405 hrs (18%) 2014 = 542 hrs (25%)
Rush Ck. – County Road	2013 = 197 hrs (27%) 2014 = 222 hrs (30%)	2013 = 172 hrs (23%) 2014 = 195 hrs (26%)	2013 = 42 hrs (6%) 2014 = 79 hrs (11%)	2013 = 411 hrs (19%) 2014 = 496 hrs (23%)

Table 33. Rush Creek water temperature metrics from the "At Dam Site" location versus "Top of MGORD" for July 1 – September 30, 2014.

Temperature Monitoring Location	Ave Temp for July (°F)	Max/Min Temps for July (°F)	Ave Temp for August (°F)	Max/Min Temp for August (°F)	Ave Temp for Sept (°F)	Max/Min Temp for Sept (°F)
At Dam Site	60.4	63.6/56.9	58.7	61.0/57.1	58.3	61.2/53.9
Top of MGORD	65.6	68.1/61.9	65.4	67.2/64.0	63.2	65.7/58.3

Trout Growth between 2013 and 2014

The limited numbers of PIT tagged fish recaptured during the 2014 sampling was quite low compared to previous years. First, because no tags were deployed in age-0 fish during the 2013 season, no growth information was available for age-1 fish in 2014 (Table 34). Age-1 fish historically have accounted for the greatest numbers of recaptured fish with tags. Low recapture rates of age-2 and age-3 fish in 2014 also limited the ability to draw conclusions about growth rates (Table 34). From the one or two tagged fish recaptured in 2014, it appears that the growth of age-2 and age-3 fish may have improved when compared to 2013 (Table 34).

However, an examination of average weights of three size classes of brown trout caught during the past two sampling years confirms similar to slightly better growth in 2014 versus 2013 (Table 35). In the Upper Rush section, all three size classes of brown trout were, on average, larger in 2014 than in 2013 (Table 35). In the Bottomlands section, brown trout in the <125 mm size class had similar average weights in 2013 and 2014, whereas the larger size classes had slightly greater average weights in 2014 (Table 35). The average weight of brown trout ≥200 mm in the Bottomlands of 88.5 g excluded a large trout (444mm/1040g) that had moved down from the MGORD because this one fish had such a great influence on the average (122.5 g when included).

Table 34. Growth rate (g) comparisons of Rush Creek age-0 to age-1, age-1 to age-2, and age-2 to age-3 brown trout, by years.

Age Class	Growth Years	Upper Rush Growth (g)	Bottomlands Growth (g)	Fin clip or PIT Tag
Age-0 to Age-1	2006-2007	32	N/A	Ad Clip
	2008-2009	51	43	Ad Clip
	2009-2010	48	40	PIT Tag
	2010-2011	48	36	PIT Tag
	2011-2012	33	25	PIT Tag
	2012-2013	35	25	PIT Tag
	2013-2014	N/A	N/A	N/A
Age-1 to Age-2	2008-2009	N/A	N/A	Ad Clip
	2009-2010	70	54	PIT Tag
	2010-2011	73	32	PIT Tag
	2011-2012	42	28	PIT Tag
	2012-2013	42	22	PIT Tag
	2013-2014	N/A	29*	PIT Tag
Age-2 to Age-3	2010-2011	N/A	14	PIT Tag
	2011-2012	29	16	PIT Tag
	2012-2013	N/A	9	PIT Tag
	2013-2014	41**	31**	PIT Tag

*one fish **two fish

Table 35. Average weight comparisons of Rush Creek brown trout, in three size classes captured in 2013 and 2014.

	Upper Rush Section		Bottomlands Section	
Size Class	**2013 Ave Wt.**	**2014 Ave Wt.**	**2013 Ave Wt.**	**2014 Ave Wt.**
<125 mm	7.2 g	9.0 g	7.0 g	6.7 g
125-199 mm	43.1 g	47.2 g	37.0 g	39.8 g
≥200 mm	119.0 g	131.6 g	84.2 g	88.5 g*

*Excludes 444mm/1040g trout.

Because no trout residing within the MGORD were implanted with PIT tags in 2012 and 2013, there were no 2014 recaptures of PIT tagged trout to gauge the growth rates of trout less than 300 mm in length. Only one fish in the 301-375 mm size class was recaptured in 2014 and this one fish exhibited good growth (Table 27). Brown trout in the >375 mm size class exhibited better growth rates (283 g) in 2014 than in the previous four years (Table 27). Unlike previous years, in 2014 there were also fewer large trout that lost weight as they aged (Tables 27 and 28). However, these improved growth rates of larger brown trout coincided with the lowest number of fish >300 mm captured in the MGORD over the 11 seasons it has been sampled (for both single-pass and two-pass sampling efforts). In 2014, only 29 fish >300 mm in length were captured on two electrofishing passes.

Condition Factors

Between 2012 and 2013, condition factors decreased in all the Rush Creek sections. However, between 2013 and 2014 condition factors of brown trout in the Upper Rush and Bottomlands sections increased. Regardless of these slight improvements in condition factor, the fish in 2014 were considered in “poor” condition based on the values being <1.00.

Similar to 2013, the analysis of the 2014 summer water temperature data revealed that brown trout in Rush Creek spent significant portions of the summer living in physiologically stressful conditions where little or no growth probably occurred. The five to six weeks leading up to the annual fisheries sampling in September was most likely particularly poor for trout growth, based on thermal-day classifications (Table 30) and large diurnal fluctuations (Table 31). Based on these temperature regimes, it is not surprising that brown trout in Rush Creek were in poor condition when sampled. The slight improvement in condition factors and also growth rates may be due to overall lower densities of fish present in September of 2014. Both the Upper and Bottomlands sections had reduced densities of age-0 fish, thus possibly reducing competition for food items.

Annual densities of brown trout >255 mm

The principal objective of the SEF winter baseflows was to increase the amount of winter holding habitat for brown trout, which may ultimately increase the survival of older and thus larger trout in lower Rush Creek (Taylor and Knudson 2011). The 2012 Annual Fisheries Report evaluated this hypothesis by making comparisons of annual densities of brown trout greater than 255 mm (10") in length between winters with SRF and SEF baseflows (LADWP 2013). The 255 mm fish length was related to the minimum size of an age-4 brown trout in 2011 that was determined by PIT tag recaptures and length-frequency histograms for the Bottomlands and County Road sections (Taylor and Knudson 2012). The 2012 Annual Fisheries Report concluded that, *"based on the data collected to date, it does appear that lower winter baseflow is one factor of many that produces older and larger trout"* (LADWP 2013).

Continuing these analyses with the 2013 data was problematic considering that no brown trout greater than 255 mm were caught in the Bottomlands or County Road sections. In the Bottomlands section only four brown trout greater than 230 mm in length were sampled in 2013 (235, 236, 242, 247 mm). In County Road only three fish were greater than 230 mm in length (233, 235, and 246 mm). The 233 mm fish was an age-3 PIT tag recapture and the 235 mm fish was an age-5 PIT tag recapture.

Again in 2014, an analysis of brown trout greater than 255 mm in the Bottomlands section was infeasible due to a lack of larger fish captured. Excluding the MGORD tagged fish that moved down into the Bottomlands section, no fish greater than 255 mm were caught in 2014. In fact, only one brown trout >230 mm was caught in 2014.

The paucity of brown trout greater than 230 mm in length in the Bottomlands section suggest very poor survival of age-2 and older fish from September 2012 to September 2014. A combination of factors was most likely at play; however marginal-to-stressful summer water temperatures for three consecutive summers seems an obvious factor. A cursory review of the 2012 summer water temperature data suggests that this summer was more thermally stressful than 2013 (Table 36). However, the 2014 data reveals a worsening of thermal conditions from 2013 (Table 36).

According to Bell (2006), brown trout were also likely to experience high mortality rates from both the direct and indirect effects of inhabiting this temperature range. Indirect effects would include after surviving a thermally stressful summer, a brown trout undergoing the rigors of the fall spawning season, followed by enduring the other end of the thermal spectrum of near-freezing winter water temperatures. Another indirect effect of stressful summer water temperatures to trout growth and survival are temperature impacts to the viability of the stream's benthic macroinvertebrate populations. Galli (1990) reported that a Maryland fisheries study determined that many coldwater insect species were eliminated or reduced by thermal enrichment; these included important food species of trout such as mayflies, caddisflies and stoneflies. One of the thermal metrics that stressed and severely impacted the macroinvertebrates was stream temperature fluctuations (Galli 1990). Finally, Bell (2006) noted that, *"reproductive efforts may also be limited by depressed juvenile fitness following a reduction in female condition prior to spawning"*. Others researchers have also documented reduced viability in trout egg production caused by thermally stressful conditions (Campbell et al. 1992).

Table 36. Comparison of number of hours that temperature exceeded 66.2°F in Rush Creek during the summers of 2012, 2013 and 2014 at five temperature monitoring locations.

Temperature Monitoring Location	Number of Hours Temperature exceeded 66.2°F in 92-day period during 2012	Number of Hours Temperature exceeded 66.2°F in 92-day period during 2013	Number of Hours Temperature exceeded 66.2°F in 92-day period during 2014
Rush Ck. – Top of MGORD	41 hours (2%)	8 hours (0.4%)	411 hours (19%)
Rush Ck. – Bottom MGORD	428 hours (19%)	411 hours (19%)	645 hours (29%)
Rush Ck. – Old Highway 395	557 hours (25%)	482 hours (22%)	639 hours (29%)
Rush Ck. – below Narrows	514 hours (23%)	405 hours (18%)	542 hours (25%)
Rush Ck. – County Road	601 hours (27%)	411 hours (19%)	496 hours (23%)

Although implementing the SEF winter baseflow recommendation coincided with increases of brown trout >255 mm in the Bottomlands and County Road sections in 2009-2011, it appears that summer water temperature in three dry runoff year types has had a stronger influence on the production of older and larger brown trout in lower reaches of Rush Creek. If RY2015 results in a fourth consecutive dry year, the annual fisheries monitoring in September 2015 may detect further declines in Rush Creek's trout fishery.

The RSD-300 metric was developed in part to gauge the ability of Rush Creek to produce brown trout that were ≥12 inches in length, allowing comparison to the D-1631 statement that, *"prior to water diversions on Rush Creek, brown trout averaging thirteen to fourteen inches were regularly observed"*. In the Upper Rush section, a total of 87 brown trout ≥300mm have been captured in 15 seasons, an average of 5.8 fish per year. In the Bottomlands section, a total of eight brown trout ≥300 mm have been caught in seven sampling years, an average of 1.1 fish per year. In the County Road section, a total of 11 brown trout ≥300 mm have been captured in 14 seasons, an average of 0.8 fish per year. The only section of Rush Creek where brown trout ≥300 mm were regularly observed was in the MGORD. A total of 1,703 brown trout ≥300mm were captured in the MGORD during 11 sampling seasons for an average of 154.8 fish per year.

Age-0 Recruitment in Rush Creek

The availability and location of spawning habitat in Rush Creek was a concern during the development of Decision 1631 and subsequent SWRCB Orders 98-05 and 98-07. The Mono Basin EIR noted that 55 redds were found between 1985 and 1989, primarily in the uppermost 0.85 miles of Rush Creek below GLR dam (page 3D-19). Section 5.4.2 of Decision 1631 (titled Flows for Providing Fishery Habitat) stated, “There is general agreement that adult habitat and spawning habitat in Rush Creek are limited”. Much of the early instream flow recommendations centered on the stability of introduced spawning substrate. In contrast, our experience since 1999 after the fisheries sampling methods were established, was that the annual recruitment of age-0 brown trout in the Rush Creek sections was variable, yet sufficient enough to translate into ample numbers of age-1 and older fish in subsequent years. Previous annual fisheries monitoring reports have shown that wide ranges in the numbers of age-0 brown trout produced in 2000-2004 eventually translated into similar numbers of age -1 and older fish (Hunter et al. 2004 and 2005). We also stated in the Synthesis Report that “In Rush Creek, ample recruitment of age-0 brown trout has occurred the past ten years”.

During the past three Dry RY types, the numbers of age-0 brown trout have steadily declined in both annually sampled sections of Rush Creek. In the Upper Rush section, the population estimate of age-0 brown trout has declined by 41% between 2012 and 2014; and the density estimate of age-0 brown trout has declined by 51% between 2012 and 2014. Age-0 brown trout in the Bottomlands section have experienced a more precipitous decline; the population estimate has declined by 79% and the density estimate has declined by 78% during the same time period. The steeper declines in the Bottomlands section may be related lower numbers of brown trout are living long enough to reach maturity and spawn at least once. In the past two years, only five fish >230 mm were sampled in the Bottomlands section. Elliot (1987) found that in two English streams, brown trout survival decreased during droughts, much more so for age-2 fish that age-1 fish.

As the Mono Basin enters a fourth year of drought conditions, these declining numbers of age-0 fish may eventually affect the numbers of mature fish contributing to future spawning populations. The annual sampling in September of 2015 may confirm further declines in all age-classes of brown trout as well as declines in condition factors. Drought effects on brown trout populations are well documented; however the effects and suspected causes are variable. James et al. (2010) documented 66% to 80% declines in brown trout biomass in three Black Hills streams in South Dakota between early-drought and late-drought periods. These declines were attributed to flow reductions and loss of pool volume since thermal conditions remained similar. A 30-year study (1966-1996) determined that drought periods lead to increased mortality and decreased growth of brown trout (Elliot et al. 1997). This study found that summer droughts which extended into the autumn spawning period resulted in lower densities of spawning females and viable eggs. Finally, another study examined resident brown trout confined to isolated pools during two years of drought (Elliot 2000). When compared to pre-drought data, the densities of age-0 and age-1 trout were reduced. The remaining fish utilized the deeper sections of the isolated pools as refugia; to the extent that a preference was detected for cooler water with lower levels of dissolved oxygen at the bottom of the pools versus the top layer of the same pools with higher temperatures, yet more dissolved oxygen (Elliot 2000).

Methods Evaluation

In 2014, mark-recapture and depletion estimates were again used to produce population estimates on Rush Lee Vining and Walker Creeks. Block fences were cleaned twice a day, and each section met the assumption of a closed population with no block fence failures.

While there were no major changes to the channels due to peak flows, between 2013 and 2014 there were slight decreases in average widths of the two Rush Creek sections and the Lee Vining Creek main channel. The average channel width of the Walker Creek section increased slightly between 2013 and 2014. These changes in average channel widths may be a function of where the individual measurements were taken since no peak flows occurred during the 2014 runoff period. In 2014, much of the Lee Vining Creek side channel was dry. The top of the reach was dry, with surface flow emerging in several locations throughout the annual electrofishing section. There were isolated pools dispersed amongst several shallow riffles. Condition factors for fish in the side channel were 0.83 in 2012, 0.93 in 2013 and 0.89 in 2014, the lowest values in the 16-year sampling period. It is recommended that channel length and width be re-measured annually.

The PIT tagging program was resumed during the September 2014 sampling and tags were implanted in both age-0 and suspected age-1 fish. Because no tags were implanted in 2013 and less than 500 tags were implanted in 2012, the recapture of previously tagged fish was quite low in 2014. These low recapture rates limited inferences about trout growth during the third year of drought in the Mono Basin. Resumption (and continuation) of the PIT tagging program is important as the fourth year of drought starts and the fisheries monitoring program moves towards its post-settlement phase.

Trout size classes (0-124, 125-199, and ≥200 mm) developed and discussed during the 2008 annual report should continue to be used in the future (Hunter et al. 2008). Using these size classes provides for long-term consistency as well as year to year consistency with the annual fisheries data sets.

To ensure that electrofishing sampling can be conducted safely and efficiently, flows in Rush and Lee Vining creeks not exceed 40 cfs. (± 5 cfs.) during the annual sampling period. Allowances for flow variances to allow for safe wading conditions and effective sampling were included in the new Terms of Settlement.

Finally, the 2015 RY appears to be an extremely dry-year and probably the driest of the four consecutive years. Storage levels in GLR are currently low and projected to most likely be considerably lower during the summer of 2015. Thus, monitoring water temperature will once again be important as well as continuing the fisheries sampling at the same time period in September.

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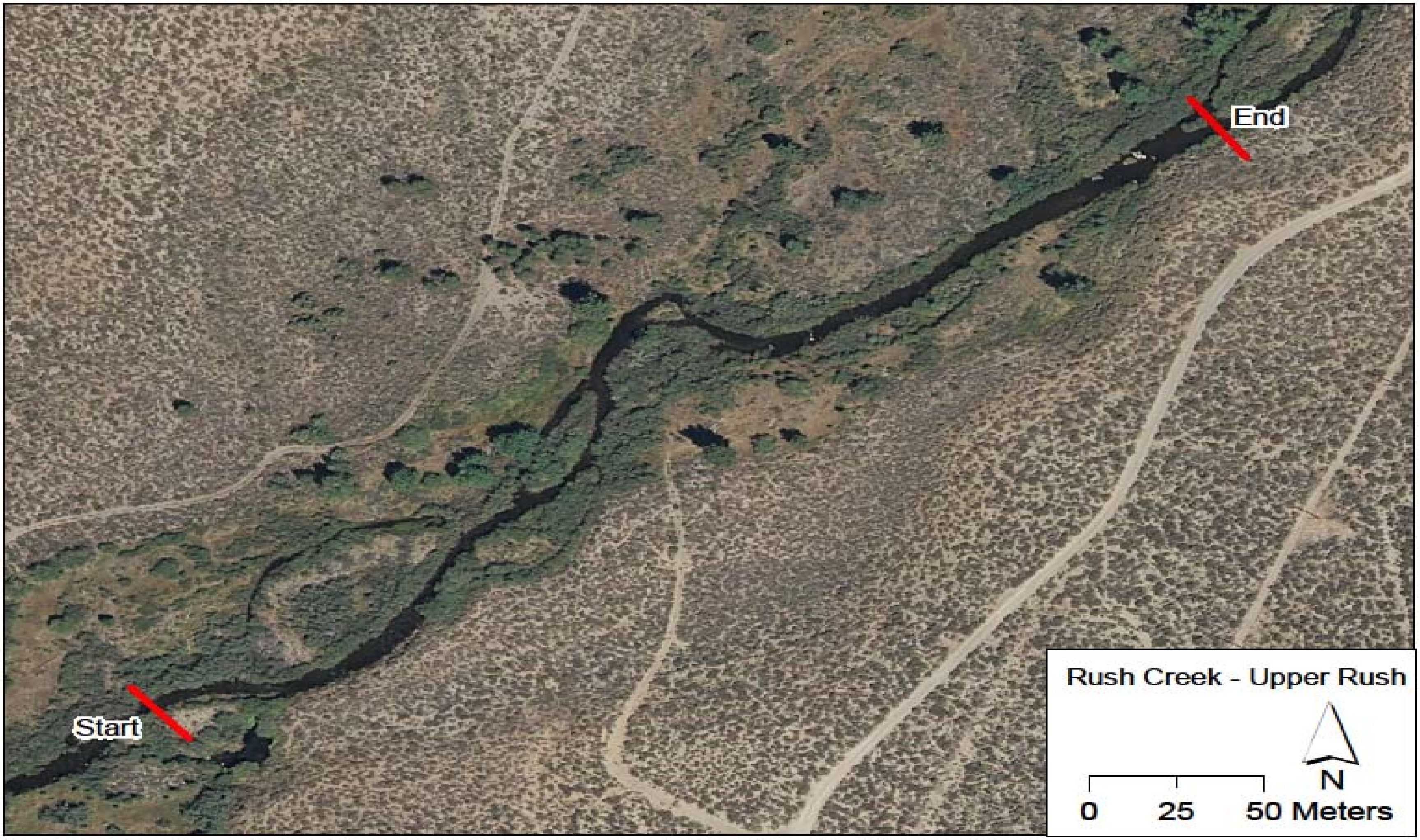
Appendices for the 2014 Mono Basin Annual Fisheries Report

Appendix A: Aerial Photographs of Long-term Monitoring Sections.




End
Start
Rush Creek - Bottomlands
N
0
25
50 Meters


End
Start
Rush Creek - MGORD
N
0
100
200 Meters


End
End
B-1 Side Channel
Main Channel
Start
Start
Lee Vining Creek- Main and B-1 Side Channels
0
20
40 Meters
N


Start
End
Walker Creek
N
0
12.5
25 Meters

Section 4

Investigating Methodologies For Assessing Woody Riparian Vigor For RY 2015-16

Investigating Methodologies for Assessing Woody Riparian Vigor

In preparation for the RY2015 monitoring season, two methodological strategies for measuring woody riparian vigor are being investigated by the Humboldt State University River Institute, with SWRCB Stream Scientist Dr. William Trush as the Principal Investigator and two undergraduate students Lorena Guerrero and Sarah Wofford.

Inter-Nodal Stem Growth to Assess Woody Riparian Vigor

Of primary interest is a straightforward, quantitative methodology for objectively evaluating performance of prescribed SEF peak releases:

> The stream monitoring team (SMT) shall measure up to ten years of cottonwood (*Populus*) stem growth on 50 branches at ten floodplain locations within Lower Rush Creek and four floodplain locations within Lee Vining Creek. Measurements using an inside micrometer shall be taken at the absolute four cardinal directions of each selected tree commencing from the lateral meristem then continuing from node-to-node corresponding to each year's growth. Trees measured shall be marked with an aluminum tag with a unique serial number for subsequent measurement. Specific branches measured will also be tagged. The measurement locations shall be provided on an aerial photograph to the Division. Annually thereafter, the SMT shall measure the most recent internode growth of tagged trees on Lower Rush Creek and Lee Vining Creek. These data will be used to calculate specific growth rates for assessing the vigor of individual trees. Annual trunk growth in the cottonwood trees assessed for vigor also shall be measured using a 16” 2-thread 0.200” diameter increment borer. Annually thereafter, the SMT shall measure the diameter breast height (DBH) of tagged trees, with the aluminum identification tags positioned at DBH. The tree ring data will establish a record of annual growth which will then be compared to annual inter-nodal growth rates used to assess vigor. Subsequent annual DBH measurements will be converted to ring size thereafter.

In preparation for the RY2015 field season, cottonwoods on the Mad River Floodplain (near Humboldt State University in Arcata, CA) are being sampled to assess variable annual nodal growth on tree aspect, architecture, and age. These findings will be used to refine a field methodology that will be applied to Rush and Lee Vining creek floodplains. This effort has required (a) a literature review and synthesis and (b) sampling local cottonwoods to quantify potential sampling biases/errors (e.g., Will sampling different parts of a tree give different results?).

Measurement of inter-nodal growth on cottonwood trees is a non-invasive method that can be used to assess tree vigor. The assessment is conducted by measuring the lowermost branches at each of the four cardinal directions of the tree, commencing with the lateral meristem and measuring, to the nearest millimeter, from bud scar to bud scar backward toward the trunk of the tree for the requisite number of years. To account for asymmetrical branch growth due to aspect, the lengths were averaged among sampled branches for each year's growth. These data were plotted against annual runoff (ac-ft) to determine if the dependent and independent variables were inter-related. Consistency between measurements of lower and higher branches (Figure 1) implies a flexible method. We are in the process of preparing tree core data to corroborate the inter-nodal data.

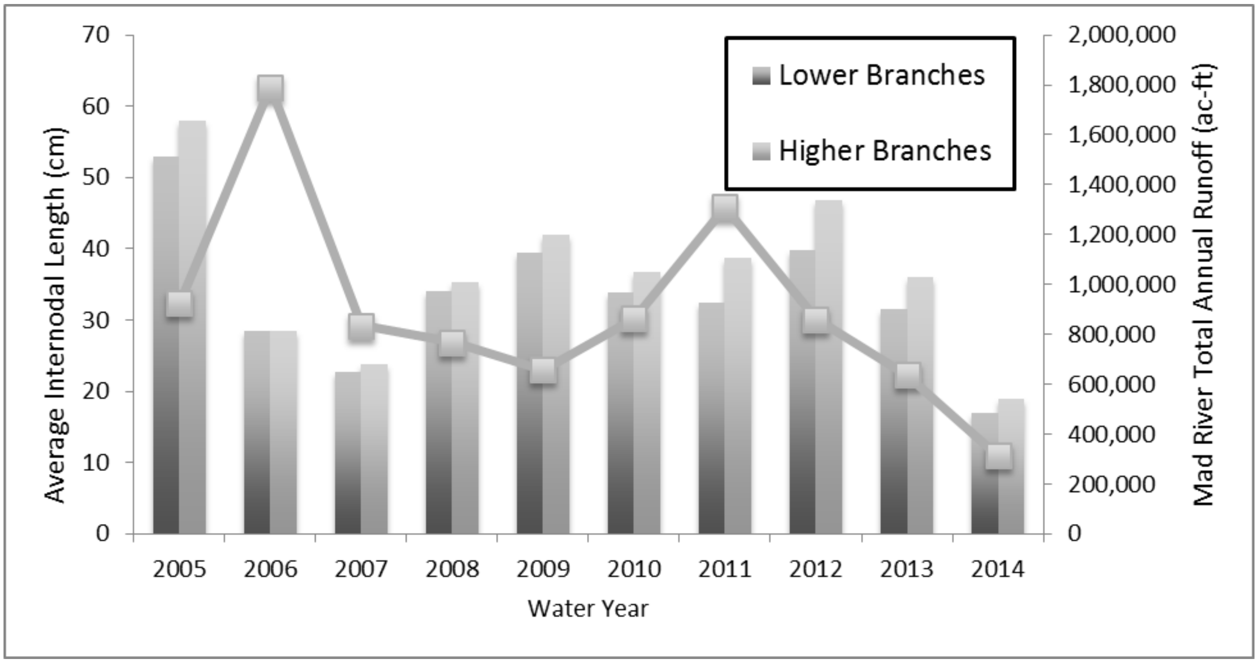


Figure 1. Lower and higher intermodal branch lengths for WY2005 to WY2014 on Mad River floodplain cottonwoods with total annual runoff (ac-ft).

Correlation of average intermodal cottonwood growth and total annual runoff looks promising from Figure 1. However, we will be exploring other hydrological indicators other than total annual runoff. For example, WY2006 was a very wet year yet average intermodal growth was close to that of 2007, a considerably drier water year. Most of the annual runoff in WY2006 occurred before early-April. The spring through summer recession WY2006 hydrograph was similar to that of WY2007.

Sap Flow Measurement to Assess Woody Riparian Vigor

The second ‘vigor assessment’ technique is measurement of an immediate physiological response, by cottonwoods and willows to rapidly increasing water availability, that most directly links the SEF’s to woody riparian plant response. Methods for measuring sap flow are being tested on individual trees in a nearby floodplain March through early-May.

Background

Assessment of sap flow is a key processes essential for the SEFs to recover ecological integrity of the floodplain (Smith and Allen 1996; Pataki et al. 2005; Nagler et al. 2007; Moore and Owens 2012). Woody plant growth and vigor are proportional to water transport through sapwood, where stem sap flux density would be expected to be high on vigorous trees growing in ideal environments as opposed to those stressed. Further, stem sap flow responds to stressors rapidly showing a marked spike in stress response within 24 hours. Sap flow measurement arrays have a broad temporal resolution, with automated data collection intervals as short as 30 minutes for a total duration of one week to 200 days. Many different sampling arrays are available. In general, the method works by measuring changes in the temperature field around a heater, allowing mathematical derivation of sap flow. Instruments can be installed on branches or on the tree’s bole. Allometric scaling calculations allow measurements from several branches or trees to assess stand vigor. Sap flow measurements are superior to leaf stomatal conductance, or porometry analysis, because they eliminate confounding factors such as leaf age or position on the tree. Sap flow measurements help complete the soil water budget, if desired, allowing plant transpiration to be parsed out from soil water evaporation.

Methodology

Thermal Dissipation Probe (TDP) (Thermal Dissipation Sap Velocity Probe for Measurement of Sap Flow in Plants. Dynamax Inc., August 22, 1997) arrays are used to measure sap flow in cottonwoods and other diffuse porous species to account for radial and vertical sap conduction. This method utilizes two small needle probes inserted radially into the tree trunk 40 mm apart, one on top of the other. The upper needle is constantly heated while the lower needle acts as a reference. Temperature differences between the two needles are recorded by an automated data logger. Stem sap flux density is calculated using the temperature differential and other tree characteristics.

Deployment

Two technicians are required to install TDP arrays. Because sap flow varies radially in large trees, each probe should be installed on the same side of each tree; selection of an absolute cardinal direction will ensure accuracy. Placing the probes on the north side of the tree will reduce ambient gradients from the sun. The probe should be installed 1 to 2 meters up from the ground to reduce temperature gradients. To install the probe a 4 x 10 cm rectangle of bark must be removed from the selected side of sample trees. Two holes, about 40 mm apart, for the temperature probes will be made using a 0.076” drill bit and drilled to a depth of 80 mm. The installation site should be rinsed with hydrogen peroxide to prevent infection and speed the healing process. After cleansing the site with hydrogen peroxide, the probes may be inserted. Once the probes are inserted, an insulating jacket should be wrapped around the trunk between the probes (though the probes would be removed by approximately mid-September). The probes’ attached cables can then be securely fastened to the tree. The data logger can then be connected and will not need adjusting until data are ready to be retrieved. The drill bit must be rinsed with 10 percent chlorine bleach solution to prevent spreading pathogens between trees.

If we recommend measuring sap flow as a performance measure for the SEFs, a maximum of five cottonwoods on the 8-Floodplain and 4-Floodplain in Lower Rush Creek and two cottonwoods in Lower Lee Vining Creek (including those situated near piezometers) will be monitored in RY2015. With a predicted low RY2015 snowmelt runoff, this year’s monitoring will be considered a trial-run.

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Section 5

Mono Basin Waterfowl
Habitat and Population Monitoring
2014-15

Mono Basin Waterfowl Habitat Restoration Monitoring

2014 Mono Lake Compliance Report

In 2014 the Los Angeles Department of Water and Power (LADWP) conducted the following monitoring in compliance with the 1996 Mono Basin Waterfowl Habitat Restoration Plan (Plan) (LADWP 1996) and the reports are contained within:

- Summer waterfowl ground counts, brood surveys and documentation of habitat use
- Fall aerial waterfowl surveys at Mono Lake, Bridgeport Reservoir and Crowley Reservoir
- Still-image photography of waterfowl habitats at Mono Lake, Bridgeport Reservoir and Crowley Reservoir taken from a helicopter
- Landtype mapping and inventory of lake-fringing habitats
- Riparian and lake-fringing wetland vegetation monitoring
- Lake limnology including meteorological, physical/chemical, phytoplankton, and brine shrimp population monitoring
- Surveillance for saltcedar (*Tamarix* spp.) during summer waterfowl surveys

Summary of Findings

Conditions

The 2014 runoff year in the Mono Basin (April 1, 2014 - March 31, 2015) was a “dry” year type with 48% of average runoff predicted. This was the third consecutive dry year, and the gradual decline in lake elevation that began in spring of 2012 as a result of the drought continued. Mono Lake dropped a total of 1.8 feet during 2014 to a low of 6378.9 feet by December. In 2014 Mono Lake was at its lowest elevation since the Mono Basin Waterfowl Restoration Plan was adopted in 1996.

Waterfowl

Breeding waterfowl at Mono Lake have been responsive to changes in lake elevation as the number of broods has been positively correlated with increases in lake elevation and subsequent increases in brood habitat in the form of seasonal and semi-permanent ponds. Over the last three years, the decline in lake elevation has resulted in the gradual drying of many seasonal and semi-permanent ponds used by breeding waterfowl. The numbers of broods seen in 2014 was the lowest seen since ground-based surveys began in 2002, and was significantly lower than the 14-year mean.

In contrast to breeding waterfowl populations, no direct or simple relationship between fall waterfowl populations and lake elevation or lake elevation changes has been evident. In 2014, total fall waterfowl numbers at Mono Lake, Bridgeport and Crowley Reservoirs were within the 14-year mean, although the number of waterfowl at Bridgeport Reservoir was the lowest recorded in all survey years. The level of Bridgeport Reservoir was very low in 2014 and this may at least partly explain the reduced use of this site through direct or indirect processes.

Limnology

In 2014 the limnological conditions at Mono Lake included increased winter and summer water temperatures, reduced oxygen levels, increased phytoplankton concentrations and reduced lake transparency. The most striking and obvious limnological pattern in 2014 noted by many familiar with Mono Lake was how green the lake was throughout the summer months, a time of year the lake's water is typically most clear. Lake transparency was very low throughout the year and the average mid-summer Secchi depth was over three times less than is typically observed.

The excess algal biomass present may have resulted in self shading, an attenuation of light transmission through the water column, and the inhibition of photosynthesis by plankton. Increased senescence of light-limited plankton may have resulted in reduced oxygen availability throughout the water column. Although plankton numbers were sufficient to support shrimp populations, early hatching in spring coupled with low second generation summer recruitment impacted fall adult *Artemia* numbers. The early *Artemia* peak abundance continues a long term trend of shift in seasonal abundance to earlier in the year. Despite earlier timing of hatching, long-term parameters indicate only a slightly below- average seasonal peak in adult *Artemia* with mean abundance 8% lower than the long term mean. A substantial decrease in average adult *Artemia* numbers, as occurred in 2014, is typical during 2nd year post-meromixis conditions.

Landtype mapping and vegetation monitoring

2014 marks the fourth time landtype mapping and vegetation monitoring transects have been conducted since implementation of the Plan. Landtype mapping has been conducted in the following years and at the following elevations: 1999 (6384.2 feet), 2005 (6382.6 feet), 2009 (6381.9 feet), and 2014 (6380.1 feet). The lower lake elevation in 2014 relative to the 1999 water surface elevation resulted in an additional 1,817 acres of exposed lakeshore area and a 331 acre increase of island area. Open water habitats such as freshwater and brackish ponds and freshwater input areas such as ria which are important and somewhat limited habitats for waterfowl at Mono Lake were less abundant at the lower lake level. The acreage of open water habitats accounted for only 95 acres in 2014, while 241 acres of open water habitats were mapped in 1999 when the lake was 4.1 feet higher. Waterfowl habitats such as these have varied in distribution and extent, depending on lake elevation, and lake elevation changes, as noted during annual waterfowl monitoring. Improvements to the classification of water habitats during the 2014 landtype mapping were supported by salinity sampling of these water habitats conducted during waterfowl surveys. Data from lake-fringing wetland transects indicates the establishment of later seral stage wetland species.

Recommendations

SWRCB Order WR 98-05 directed LADWP to implement restoration measures in the Mono Basin Waterfowl Habitat Restoration Plan and conduct monitoring to assess the success of waterfowl habitat restoration efforts. The monitoring of waterfowl populations in the Mono Basin was to continue until at least the year 2014, or until the targeted lake level (6,392 foot elevation) was reached and the lake cycled through a complete wet/dry cycle (LADWP 2000). As of 2014, Mono Lake had not yet reached the targeted lake elevation as recovery of the lake to the target elevation is taking longer than initial model predictions.

As part of the 2015 compliance reporting I recommend LADWP prepare a synthesis report that incorporates monitoring data from all components of the 1996 Waterfowl Restoration Plan: hydrology, lake limnology and secondary producers, vegetation status in riparian and lake-fringing wetland habitat, and waterfowl population surveys and studies. A synthesis of the data collected as part of the Waterfowl Restoration Plan will allow the State Water Resources Control Board, LADWP and interested parties the ability to evaluate the success of waterfowl habitat restoration efforts to date, and the efficiency and efficacy of the program at fulfilling both the requirements and intent of the Plan. Recommendations for modifications to the current program or for management of waterfowl habitat at Mono Lake should be addressed, if warranted based on the results of this data-driven analysis.

Debbie House March 24, 2015

Debbie House

Interim Mono Basin Waterfowl Monitoring Program Director

Los Angeles Department of Water and Power (LADWP). 1996. *Mono Basin Waterfowl Habitat Restoration Plan.* Prepared for the State Water Resources Control Board. In response to Mono Lake Basin Water Right Decision 1631.

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APPENDIX 1

Limnology

2014 Annual Report

Mono Lake Limnology Monitoring

Prepared by:

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Los Angeles Department of Water and Power

Bishop, CA.

Prepared for: State Water Resources Control Board

March 2015

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INTRODUCTION

Limnological monitoring was conducted in 2014 at Mono Lake as required under the State Water Resources Control Board Order No. 98-05. The limnological monitoring program at Mono Lake is one component of the Mono Basin Waterfowl Habitat Restoration Plan (LADWP, 1996). The purpose of the limnological monitoring program as it relates to waterfowl is to assess limnological and biological factors that may influence waterfowl use of lake habitat (LADWP 1996). The limnological monitoring program consists of four components: meteorological, physical/chemical, phytoplankton, and brine shrimp population data.

An intensive limnological monitoring of Mono Lake has been funded by Los Angeles Department of Water and Power (LADWP) since 1982. The Marine Science Institute (MSI), University of California, Santa Barbara served as the principle investigator, and Sierra Nevada Aquatic Research Laboratory (SNARL) provided field sampling and laboratory analysis technicians up to July 2012. After receiving training in limnological sampling and laboratory analysis methods from the scientists and staff at MSI and SNARL, LADWP Watershed Resources staff assumed responsibility for the program, and has been conducting limnological monitoring of Mono Lake since July of 2012.

This report summarizes monthly field sampling for the year of 2014. Laboratory support including the analysis of ammonium and chlorophyll *a* in 2014 was provided by Environmental Science Associates, Davis, California.

METHODS

Methodologies for both field sampling and laboratory analysis followed those specified in *Field and Laboratory Protocols for Mono Lake Limnological Monitoring (Field and Laboratory Protocols)* (Jellison, 2011). The methods described in *Field and Laboratory Protocols* are specific to the chemical and physical properties of Mono Lake and therefore may vary from standard limnological methods (e.g. Strickland and Parsons 1972). The methods and equipment used by LADWP to conduct limnological monitoring was consistent and followed those identified in *Field and Laboratory Protocols* except where noted below.

Meteorology

One meteorological station on Paoha Island provided weather data in 2014. The Paoha Island measuring station is located approximately 30 m from shore on the southern tip of the island. The base of the station is at 1948 m above sea level, several meters above the current surface elevation of the lake. Sensor readings are made every second and stored as either ten minute averages or hourly values in a Campbell Scientific CR 1000 datalogger. Data are downloaded to a storage module which is collected periodically during field sampling visits.

At the Paoha Island station, wind speed and direction (RM Young wind monitor) are measured by sensors at a height of 3 m above the surface of the island and are averaged over a 10-minute interval. During the ten minute interval, maximum wind speed is also recorded. Using wind speed and direction measurements, the 10-minute wind vector magnitude and wind vector direction are calculated. Hourly measurements of photosynthetically available radiation (PAR, 400 to 700 nm, Li-Cor 192-s), ten minute averages of relative humidity and air temperature (Vaisalia HMP35C), and total rainfall (Campbell Scientific TE525MM-L tipping bucket) are also stored. The minimum detection limit for the tipping bucket gage is 1 mm of water. The tipping bucket is not heated therefore the instrument is less accurate during periods of freezing due to sublimation of ice and snow.

The daily mean wind speed, maximum mean wind speed, and relative humidity were calculated from 10-minute averaged data from the Paoha Island site.

Field Sampling

Sampling of the physical, chemical and biological properties of the water including the *Artemia* community was conducted at 12 buoyed stations at Mono Lake (Figure 1). The water depth at each station at a lake elevation of 1,946 meters is indicated on Figure 1. Stations 1-6 are considered western sector stations, and stations 7-12 are eastern sector stations. Surveys were generally conducted around the 15th of each month.

Physical and Chemical

Sampling of the physical and chemical properties included lake transparency, water temperature, conductivity, dissolved oxygen, and nutrients (ammonium). Lake elevation data was obtained directly from the Mono Lake Committee website (http://www.monobasinresearch.org/data/levelmonthly.php) and LADWP database records for data recorded prior to 1979. Lake transparency was measured at all 12 stations using a Secchi disk. A high-precision conductivity temperature-depth (CTD) profiler (Idronaut, Model 316 Plus) was used to record conductivity at nine stations (2, 3, 4, 5, 6, 7, 8, 10 and 12). The CTD is programmed to collect data at 200 millisecond intervals. The CTD was lowered to the bottom at a rate of ~0.2 meters/second, therefore data collection occurred at approximately 4 cm depth intervals. Conductivity data was collected from the CTD field sampling device on a monthly basis. However, data from February is not available as the CTD unit was undergoing repair due to malfunction. Data from October, November and December are also not available due to additional malfunction of the CTD probe. The backup meter used during this time period also did not appear to function reliably. In situ conductivity measurements were corrected for temperature (25˚C) and reported at one meter intervals beginning at one meter in depth down to the lake bottom. Conductivity data is used to evaluate the salinity profile of the lake. In addition to successful repair of the CTD probe an additional new CTD probe has been purchased by LADWP for future monitoring.

Dissolved oxygen was measured at one centrally located station (Station 6). Dissolved oxygen concentration was measured with a Yellow Springs Instruments Rapid Pulse Dissolved Oxygen Sensor (YSI model 6562). Readings were taken at one-meter intervals throughout most of the water column, and at 0.5 meter intervals in the vicinity of the oxycline or other regions of rapid change. Data are reported for one-meter intervals only.

Monitoring of ammonium in the epilimnion was conducted using a 9-m integrated sampler at stations 1, 2, 5, 6, 7, 8, and 11. An ammonium profile was developed by sampling at station 6 from eight discrete depths (2, 8, 12, 16, 20, 24, 28, and 35 meters) using a vertical Van Dorn sampler. Samples for ammonium analyses were filtered through Gelman A/E glass-fiber filters and following collection, immediately placed onto dry ice and frozen in order to stabilize the ammonium content (Marvin and Proctor, 1965). Ammonium samples were transported on dry ice back to the laboratory transfer station. The ammonium samples were stored frozen until delivered to the University of California Davis Analytical Laboratory (UCDAL) located in Davis, California. Samples were stored frozen until analysis.

Phytoplankton

Chlorophyll a sampling

Monitoring of chlorophyll a in the epilimnion was conducted using a 9-m integrated sampler at stations 1, 2, 5, 6, 7, 8, and 11. A chlorophyll profile was developed by sampling at station 6 from seven discrete depths (2, 8, 12, 16, 20, 24, and 28 meters) using a vertical Van Dorn sampler. Water samples were filtered into opaque bottles through a 120 µm sieve to remove all life stages of *Artemia*. Chlorophyll *a* samples were kept cold and transported on ice back to the laboratory transfer station located in Sacramento, CA.

Brine Shrimp

Artemia sampling

The *Artemia* population was sampled by one vertical net tow from each of twelve stations (Figure 1). Samples were taken with a plankton net (0.91 m x 0.30 m diameter, 118 µm Nitex mesh) towed vertically through the water column. Samples were preserved with 5% formalin in Mono Lake water. When mature females were present, an additional net tow was taken from four western sector stations (1, 2, 5 and 6) and three eastern sector stations (7, 8 and 11) to collect adult females for fecundity analysis including body length and brood size. Live females collected for fecundity analysis were kept cool and in low densities during transport to LADWP laboratory in Bishop, CA.

Laboratory Analysis

Ammonium

Nitrogen is the primary limiting macronutrient in Mono Lake as phosphate is super-abundant throughout the year (Jellison et al 1994 in Jellison 2011). External inputs are low, and vertical mixing controls much of the annual internal recycling of nitrogen.

Starting in August 2012, the methodology used by UCDAL for ammonium was flow injection analysis. In July 2012, this method was tested on high salinity Mono Lake water and was found to give results comparable to previous years. This method has detection limits of approximately 2.8 µM. Immediately prior to analysis, frozen samples were allowed to thaw and equilibrate to room temperature, and were shaken briefly to homogenize. Samples were heated with salicylate and hypochlorite in an alkaline phosphate buffer (APHA 1998a, APHA 199b, Hofer 2003, Knepel 2003). EDTA (Ethylenediaminetetraacetic acid) was added in order to prevent precipitation of calcium and magnesium, and sodium nitroprusside was added in order to enhance sensitivity. Absorbance of the reaction product was measured at 660 nm using a Lachat Flow Injection Analyzer (FIA), QuikChem 8000, equipped with a heater module. Absorbance at 660 nm is directly proportional to the original concentration of ammonium, and ammonium concentrations were calculated based on absorbance in relation to a standard solution.

Chlorophyll a

Chlorophyll *a* is the most abundant form of chlorophyll found bound within the cells of the algae comprising the phytoplankton community at Mono Lake. Chlorophyll *a* is therefore monitored as an indicator of phytoplankton activity and abundance.

In 2014 the determination of chlorophyll *a* was done by fluorometric analysis following acetone extraction. Fluorometry was chosen, as opposed to spectrophotometry, due to higher sensitivity of the fluorometric analysis, and because data on chlorophyll *b* and other chlorophyll pigments were not needed.

At the laboratory transfer station in Sacramento, water samples (200 mL) were filtered onto Whatman GF/F glass fiber filters (nominal pore size of 0.7 µm) under vacuum. Filter pads were then stored frozen until they could be overnight mailed, on dry ice, to the University of Maryland Center for Environmental Science Chesapeake Biological Laboratory (CBL), located in Solomons, Maryland. Sample filter pads were extracted in 90% acetone and then refrigerated in the dark for 2 to 24 hours. Following refrigeration, the samples were allowed to warm to room temperature, and then centrifuged to separate the sample material from the extract. The extract for each sample was then analyzed on a fluorometer. Chlorophyll *a* concentrations were calculated based on output from the fluorometer. Throughout the process, exposure of the samples to light and heat was avoided.

The fluorometer used in support of this analysis was a Turner Designs TD700 fluorometer equipped with a daylight white lamp, 340-500 nm excitation filter and >665 nm emission filter, and a Turner Designs Trilogy fluorometer equipped with either the non-acid or the acid optical module.

Artemia Population Analysis and Biomass

An 8x to 32x stereo microscope was used for all *Artemia* analyses. Depending on the density of shrimp, counts were made of the entire sample or of a subsample made with a Folsom plankton splitter. When shrimp densities in the net tows were high, samples were split so that approximately 100-200 individuals were subsampled. Shrimp were classified as nauplii (instars 1-7), juveniles (instars 8-11), or adults (instars >12), according to Heath's classification (Heath, 1924). Adults were sexed and the reproductive status of adult females was determined. Non-reproductive (non-ovigerous) females were classified as empty. Ovigerous females were classified as undifferentiated (eggs in early stage of development), oviparous (carrying cysts) or ovoviviparous (naupliar eggs present).

An instar analysis was conducted at seven of the twelve stations (Stations 1,2,5,6,7,8, and 11). Nauplii at these seven stations were further classified as to specific instar stage (1-7). Biomass was determined from the dried weight of the shrimp tows at each station. After counting, samples were rinsed with tap water and dried in aluminum tins at 50°C for at least 48 hours. Samples are weighed on an analytical balance immediately upon removal from the oven.

Artemia Fecundity

Immediately upon return to the laboratory, ten females from each sampled station were randomly selected, isolated into individual vials, and preserved with 5% formalin. Female length was measured at 8X from the tip of the head to the end of the caudal furca (setae not included). Egg type was noted as undifferentiated, cyst, or naupliar. Undifferentiated egg mass samples were discarded. Brood size was determined by counting the number of eggs in the ovisac and any eggs dropped in the vial. Egg shape was noted as round or indented.

Artemia Population Statistics

Calculation of long-term *Artemia* population statistics followed Jellison and Rose (2011). Daily values of adult *Artemia* between sampling dates were linearly interpolated in Microsoft Excel. The mean, median, peak and centroid day (calculated center of abundance of adults) were then calculated for the time period May 1 through November 30. Long-term values were determined by calculating the mean, minimum and maximum values for these parameters for the time period 1979-2014.

RESULTS

Meteorology

Wind Speed, relative humidity, air temperature and precipitation data from the weather station at Paoha Island are summarized monthly for 2014.

Wind Speed and Direction

Mean daily wind-speed varied from 1.3 to 13.5 m/sec with an overall mean for this time period of 3.4 m/sec (Figure 2). The daily maximum 10-min averaged wind speed on Paoha Island averaged 1.5 times the mean daily wind speed. The maximum recorded 10-min reading of 19.7 m/sec occurred on the afternoon of December 11th. As has been case in previous years, winds were predominantly from the south (mean 191 degrees).

Air Temperature

Average daily air temperatures as recorded at Paoha Island ranged from a yearly low of -8.69°C on December 31, 2014 to a yearly high of 24.38°C on July 13 (Figure 3). Early 2014 winter temperatures (January through February) ranged from -6.3°C to 10.4°C with an average maximum daily temperature of 9.7°C (almost 3 times greater than in 2013). The average maximum daily summer temperature (June through August) was 26.8°C, which was unchanged from last year. Overall average daily air temperatures were 10.2°C in 2014 compared to 8.9˚C in 2013.

Relative Humidity and Precipitation

The mean relative humidity for the period January 1st – December 31st, 2014 was 53% (Figure 4). Mean relative humidity was negatively correlated with both daily mean wind speed ($r = -0.365$, $p<0.001$, $n=365$), and maximum 10-minute mean wind speed ($r = -0.367$, $p<0.001$, $n=365$).

The total precipitation measured at Paoha Island was 271.8 mm. From January to February precipitation was moderate producing 60 mm of rain with half of this amount (30.5 mm) occurring on February 15th (Figure 5). Spring (March-May) months produced less rain (48 mm) followed by summer (June- August) months (10 mm). Fall (September-November) precipitation increased to 66 mm before peaking in the month of December (81 mm). The largest rain event of the year produced 66 mm and occurred on December 11th. The greatest frequency of rain days (6) occurred in the month of February.

Physical and Chemical

Surface Elevation

The surface elevation of Mono Lake in January 2014 was 6380.4 feet. A slight increase in elevation to 6380.7 feet was observed in April. Starting in May lake elevation started to decline and this a gradual decrease in elevation continued through December. From the 2014 high of 6380.7 feet in April, the lake dropped a total of 1.8 feet to a low of 6378.9 feet by December. For 2014 the greatest change in surface elevation (0.3 feet) occurred in late summer from August to September and early fall from September to October.

Figure 6 shows lake elevation 1979 through 2014 and the mixing regime observed each year. As will be discussed below, Mono Lake continued to exhibit a monomictic mixing regime in 2014.

Transparency

The lowest spring Secchi (average) depth was 0.47 m +/- 0.02 m in April (Table 1, Figure 7). Secchi depth increased through mid-June when transparency was 0.89 m +/- 0.04 m. As *Artemia* grazing reduced midsummer phytoplankton, lakewide transparency increased to a maximum of 1.50 m +/- 0.06 m in July. Secchi depths began to decrease through the fall, and remained between 0.47 m and 0.58 m from October through December. Overall Secchi depth transparency was greatly reduced compared to last year. Average Secchi depth in July was more than three times lower (1.50 m) in 2014 compared to 2013 (5.08 m).

Water Temperature

The water temperature data from Station 6 indicate that Mono Lake remained monomictic in 2014 as the lake was thermally stratified from late spring to early fall with turnover occurring once later in the fall (Table 2, Figure 8). In April the thermocline began to form at 3-4 m (as indicated by the greater than 1°C change per meter depth) and fluctuated between 9 and 15 m through September before deepening to 18 m by October. By mid-November temperatures were isothermic from 1 m to 40 m indicating the onset of holomixis (Table 2, Figure 8). Holomixis persisted throughout December as temperature data indicate little change with water temperatures at 8.2°C from 2 meters gradually declining to 7.9°C at 38 m. Average water temperatures (entire water column) were warmer in all months in 2014 compared to 2013. The greatest difference in average temperatures were observed primarily in winter (November, December, February, March) and summer months (June - August). During these months average temperatures were about 2°C higher. Average water temperatures (0-22 m) in July were 14.6°C compared to 12.4˚C in 2013. Average water temperatures in December (0-40 m) were 8.1°C compared to 6.0˚C in 2013.

Dissolved Oxygen
Dissolved oxygen (DO) levels at Station 6 were indicative of historical limnological mixing patterns observed at Mono Lake. In 2014 Mono Lake had one period of fall turnover marking the 3rd continuous year of monomictic conditions. DO concentration in winter/spring months within the first 15 m of the water column ranged as low as <1 mg/l in March to as high as 6.4 mg/l in May (Table 4, Figure 10*).* In May, DO levels in the first 6 m of the water column were about twice as low (6.4 mg/l) as 2013 levels (12.9 mg/l). Dissolved oxygen levels at Mono Lake are typically greatest in spring months as phytoplankton blooms follow increased sunlight and temperature levels. DO levels near the lake substrate (39 m) decreased from February to May (1.8 to 0.3 mg/l) prior to full onset of meromixis. In June, Mono Lake was thermally stratified with meromictic conditions persisting through September. DO levels in the middle of summer (June - August) were unusually low (<1.1 mg/L) throughout the water column. For comparison, last year epilimnetic DO levels ranged from 1.9 to 7.3 mg/L during this same time period. In October the thermocline began to slowly breakdown prior to holomixis. In the fall average epilimnetic DO concentrations were highest in November (9.3 mg/l) and were lowest in October (1.8 mg/l) as monomolimnetic hypoxic waters began to mix with epilimnetic waters. (Table 4, Figure 10). Mono Lake remained monomictic in December.

Conductivity
The winter of 2014 marked the third consecutive year of monomixis at Mono Lake. Mono Lake surface elevation slowly increased in the beginning of 2014 and reached its peak in April as freshwater inputs from snowmelt likely contributed to vertical salinity stratification. Conductivity data is used to evaluate the salinity profile of the lake. Specific conductivities for April ranged from 83.6 to 85.9 mS/cm above 14 meters and from 85.3 to 88.5 mS/cm below 14 meters (Table 3).

As thermal and chemical stratification became more prominent in the summer months the greatest difference between epilimnetic and hypolimnetic specific conductivities were reported in July (Table 3, Figure 9). For July specific conductivity averaged 79.3 mS/cm in the epilimnion and 88.0 mS/cm in the hypolimnion. By September average specific conductivity was only 3.5 mS/cm different between the epilimnion (84.0 mS/cm) and hypolimnion (87.5 mS/cm).

Ammonium
Ammonium levels were uniform (<2.8 µM) throughout the water column in early 2014 (Table 5, Figure 11) due to holomixis that occurred in late 2013. Epilimnetic ammonium levels were below the detection limit in April and May (<2.8 µM) and were between 3.3 and 7.8 µM below 20 meters. Epilimnetic ammonium levels slightly increased in June and July as *Artemia* abundance increased and excretion of fecal pellets raised the ammonium levels in the water column (Table 6). The July through October period had large increases in the level of ammonium in the

hypolimnion below approximately 20 m (14.4 to 27.7 µM). Increases in the ammonium concentration in the hypolimnion during these months is associated with increases in algal debris and *Artemia* fecal pellets as these waste products sink to the bottom and decompose (Jellison 2011). Under anoxic conditions during summer thermal stratification ammonium concentrations tend to be higher at the sediment-water interface as bacterial nitrification ceases and the adsorptive capacity of the sediments is greatly reduced due to loss of the oxidized microzone (Wetzel, 2001). Ammonium was between 3.3 and 3.9 µM and well-mixed throughout the water column by November and mixing remained complete through mid-December. This reduction in ammonium levels throughout the water column coincides with holomixis and increased uptake by phytoplankton as predation pressure from *Artemia* decreases in winter months. Average epilimnetic ammonium concentrations from integrated 9 meter samples never exceeded 3.6 µM (November) throughout the year, likely due to high phytoplankton density (Table 6).

Phytoplankton

Seasonal changes were noted in the phytoplankton community, as measured by chlorophyll *a* concentration (Tables 7 and 8, Figure 12). On the February survey, epilimnetic chlorophyll a levels averaged 57.7 µg/L (Table 8). Within the epilimnion, lakewide mean chlorophyll values decreased through the spring and reached their lowest point in the middle of summer (8.1 µg/L, Table 8). As the lake began to stratify in late spring and zooplankton grazing increased, chlorophyll levels declined from 28.7 µg/L in May, to 14.3 µg/L in June at 8 meters in depth (Table 7). In July at station 6 chlorophyll concentrations varied from 5.4 µg/L at 2 meters to 78.7 µg/L at 28 meters in the hypolimnion. Mean epilimnetic chlorophyll levels were four times greater in June (13.7 µg/L) five times greater in July (8.1 µg/L) and almost eight times greater in August (24.2 µg/L, Table 8) compared to 2013. By October as the water column began to mix the lakewide epilimnetic average had increased to 64.7 µg/l and reached its peak in December at 97.7 µg/L (Table 8). Overall both the lakewide trends (Table 8) and discrete sampling at Station 6 (Table 7) indicate changes in chlorophyll concentrations closely follow turnover conditions and fluctuations in grazing pressure from population changes of brine shrimp.

Brine Shrimp

<u>*Artemia*</u> *Population Analysis and Biomass*

Artemia population data is presented in Tables 9a through 9c as lakewide means, sector means associated standard errors and percentage of population by age class. As discussed in previous reports (Jellison and Rose 2011), zooplankton populations can exhibit a high degree of spatial and temporal variability. In addition, when sampling, local convergences of water masses may concentrate shrimp above overall means. For these reasons, Jellison and Rose have cautioned that the use of a single level of significant figures in presenting data is inappropriate, and that the reader should always consider the standard error associated with *Artemia* counts when making inferences from the data.

<u>*Artemia*</u> *Population*

Hatching of overwintering cysts had already initiated by February as the mid-February sampling detected an instar lakewide mean abundance of 35,352 +/- 4,624/m^2. The overwhelming majority (97.8%) of the instars in mid-February were instar 1 (see Table 10). Instar abundance increased through mid-March to a peak of 150,909 +/- 47,129/m^2 which was almost twice the density of April 2013 peak instar counts. Similar to 2013 in early spring adults continued to be essentially absent. The 2014 peak *Artemia* lakewide abundance of 151,123 +/-47,131/m^2 was recorded on the March 18 survey. Adults matured later in 2014 compared to 2013. By May, adults comprised less than 1% of the *Artemia* population compared to 34% in 2013. The instar analysis indicated a diverse age structure of instars 1-7 and juveniles (instars 8-11) in May. In

May, females with cysts were first recorded. By July females with cyst abundance peaked at 10,007 +/- 950/m^2 and by August reproduction decreased significantly, with instars and juveniles comprising only 8.3% of the population. The greatest summer adult *Artemia* abundance occurred in July (42,298+/-4,128/m^2). By August the adult population declined by 75% to10,776 +/- 1,839/m^2 compared to a 17% reduction in the adult population size during this same time period in 2013 (July 2013: 54,347 +/- 4,128, to August 2013:45,152 +/- 8,509/m^2) . In mid-October, adult shrimp numbered 553 +/- 111/m^2, dropping to a low of 106 +/- 31/m^2 in November and 66 +/- 28/m^2 in December.

Instar Analysis
The instar analysis, conducted at seven stations, showed patterns similar to those shown by the lakewide and sector analysis, but provide more insight into *Artemia* reproductive cycles occurring at the lake (Table 10). Instars 1 and 2 were most abundant in February and March as overwintering cysts were hatching. In April various age classes of instars 1-7 and juveniles were present and comprised approximately 99.4% of the *Artemia* population. In May a diverse age structure of instars was present, while adults comprised only 0.6% of all *Artemia*. By June juvenile and instar abundance represented about 54% of the age structure population. The presence of late stage instars and juveniles indicate survival and recruitment into the population. Instar and juvenile abundance decreased to 24.3% in July and reached a low in August of 8.3% of the *Artemia* population. Adult relative abundance decreased from 87.1% in September to 28.4% in December while instar and juvenile age classes increased from 12.9% to near 71.6% over the same period (Table 9c). The greatest reduction in lakewide *Artemia* abundance occurred from July to August (79%, Table 9a) compared to a 71% reduction from August to September in 2013. While proportions of *Artemia* age classes changed over the year, adult, juvenile and instar abundances declined considerably in November and December as anticipated (Table 9a).

Biomass
Mean *Artemia* biomass values were low in winter/spring, ranging from 1.40 gm/m^2 in February to 3.88 gm/m^2 in April (Table 11). Mean lakewide *Artemia* biomass peaked at 28.7 gm/m^2 in mid-June, and remained about the same into July, at 28.2 gm/m^2 before declining in August to 7.68 gm/m^2. By October, mean lakewide biomass had declined to 0.90 gm/m^2, and was minimal in November and December (Table 11). Biomass values were greater in the east with the exception of the month of July. In July during peak shrimp abundance biomass values were higher in the west at 30.1 gm/m^2 compared to 26.2 gm/m^2 in the east.

Reproductive Parameters and Fecundity Analysis
Table 12 and Figure 13 show the result of the fecundity analysis and lakewide reproductive parameters. In May, very low ovigery was detected therefore fecundity analysis was not conducted during this month. In June approximately 83% of females were ovigerous, with 61% oviparous (cyst-bearing), 11.3% ovoviviparous (naupliar eggs) and 10.6% undifferentiated eggs (Table 9c). From July through October, over 90% of females were ovigerous with the majority (64-88%) oviparous. Ovovivipary was over 10% in all months during this period with the exception of September (Table 9c).

The lakewide mean fecundity showed pronounced seasonal variation. The lakewide mean fecundity was initially 24.3 +/- 0.82 eggs per brood in mid-June, decreasing slightly to 18.3 +/- 0.5 eggs per brood in July (Table 12). Lakewide fecundity was 31.7 +/- 1.91 eggs per brood in August and reached a high of 67.5 +/- 2.43 eggs per brood in September. Although fecund females were documented during population analysis, densities were too low to conduct fecundity analysis of females for the month of October. The majority of fecund females (94-

99%) were oviparous, while ovoviviparous females with naupliar eggs constituted the remainder. Little difference was observed in fecundity between the western and eastern sectors. The minimum mean female length was 8.1 mm in July which corresponded with the smallest mean brood sizes for the year. The largest females (mean 9.7 mm) were recorded in September when mean brood size was also at its highest for the year. The number of indented cysts remained relatively constant near 50% with a high of 71% in July (Table 12).

Artemia Population Statistics

The calculated seasonal peak in adult *Artemia* of 42,298/m^2 was slightly below the long-term average of 45,600/m^2 (Table 13). The mean and median were also below average (13,467 vs. 19,599/m^2 and 7,602 vs 18,269/m^2). The centroid is the calculated center of abundance of adults. The centroid day of 186 in 2014 corresponds to July 5th. This is 10 days earlier than 2013 and 7 days later than 2012. The long-term mean centroid day for the time period 1979-2014 is 210 (July 29). Figure 14 shows daily lakewide mean adult *Artemia* values for 1982-2014. 2013 was the first year since the most recent episode of meromixis in 2011 that ammonium previously contained in the hypolimnion was fully available for phytoplankton. The year 2012 marked the 4th time that Mono Lake shifted from meromixis to monomixis during the period of record. There is data to suggest that years following the onset of monomixis have coincided with high adult *Artemia* abundance at Mono Lake (Figure 15). The long term data show 1989 and 2004 as the 2nd and 3rd highest adult density recorded from 1979-2013 (Table 12, Figure 14). The longest periods of meromixis, 1983-1987 and 1995-2002 ended just previous to these years (see Figure 6). Years such as 2014 that follow higher abundance years see a subsequent decline the following year of almost 50% (Table 13). Please see the appendix for a further explanation of change of ecological conditions following historic meromictic periods.

DISCUSSION

Thermal and Chemical Stratification

In 2014, Mono Lake experienced a net reduction in elevation of 1.5 feet and holomixis or complete autumn mixing for the third year in a row. Following winter holomixis, thermal stratification became evident as early as April and strong thermal stratification was present by June. Thermal stratification was observed as late as October. By November an isothermal water column was present indicating full mixing of the water column.

Conductivity data indicated the establishment of a salinity gradient beginning in March and April with the greatest difference in specific conductivity in the epilimnion and hypolimnion occurring in July and August. Conductivity began to increase in September in the epilimnion and was similar to the profile observed in 2013 (Table 3, Figure 9). Although data was not available from October through December, conductivity values are typically most consistent throughout the water column as the lake begins to fully mix in October and November. As more saline hypolimnetic water mixes with surface water conductivity increases in the epilimnion. In addition as the lake volume reduces during fall/early winter conductivity (salinity) can increase. The seasonal reduction of lake volume is apparent at this time (fall/winter) of the year and salinity may be even greater overall with reduced freshwater inflows during drought years (Figure 16).

Dissolved Oxygen

Dissolved oxygen values deviated slightly from the seasonal pattern generally observed at Mono Lake. DO levels in February and March appeared low and were only slightly higher in February compared to oxygen levels reported in November and December of 2013. Perhaps biological oxygen demand from microbial decomposition in the hypolimnion persisted throughout the water column for months after fall turnover (2013). While DO levels slowly increased during the spring, average epilimnetic DO levels (4.9 mg/L) were about 50% lower compared to 2013. During the summer months average epilimnetic DO levels were also very low (<1 mg/L) at least four times lower (4.3 mg/L) compared to 2013. Historically summer epilimnetic DO concentrations have not been much below 2 mg/L (Jellison, 1993).

As algal populations recovered in the fall due to decreasing shrimp numbers, dissolved oxygen values in the epilimnion increased. Although the lake was fully mixed by November, average dissolved oxygen levels within the first 10 meters of the lake were high (12 mg/L). In December DO levels ranged from 3.8 – 4.8 mg/L throughout the water column, more than twice as high as 2013 (1.4 mg/L, Table 4, Figure 10). Increased plankton density may have caused increases in oxygen levels going into winter months.

Ammonium and Chlorophyll

Ammonium sampling further supports the presence of a monomictic lake regime in 2014. Prior to summer stratification ammonium concentrations were similar throughout the water column. The June through October period showed large increases in the level of ammonium in the hypolimnion as algal debris and *Artemia* fecal pellets accumulated and decomposed in the hypolimnion. In addition, in the anoxic hypolimnion internal loading occurs as ammonium released from the sediments further increases ammonium levels. Ammonium concentrations were below 3.9 µM throughout the water column by mid-November and remained below 6.7 µM through mid-December. Generally low levels of ammonium in spring/winter months coincided with the greatest concentration of mean chlorophyll in the epilimnion across all stations sampled and throughout the water column at station 6.

Epilimnetic chlorophyll levels were initially moderate from February through April and decreased 42% in May and another 56% in June coincident with the increase in juvenile and adult shrimp numbers. Mean epilimnetic chlorophyll levels were lowest in July (8.1 µg/L) coinciding with peak adult *Artemia* abundance. As shrimp numbers declined in August and September chlorophyll levels nearly recovered to spring levels by September. During this time shrimp numbers were low, algal biomass increased and dissolved oxygen levels began to recover. Mean epilimnetic chlorophyll levels continued to increase throughout the year until reaching their peak in December (97.7 µg/L) almost twice that of March (52.8 µg/L) and all monthly 2013 concentration.

Brine Shrimp

Mean adult *Artemia* abundance was 48% lower in 2014 compared to 2013, and peak adult abundance was about 22% lower. Total brine shrimp numbers (adults and instars) peaked in March and were almost completely represented by early stage instars. Recruitment of early instars to the population was evident by increasing late stage instars in May and June and peak adult numbers in July. Adult abundance peaked in July and was representative of the long term trend. The centroid peak in abundance occurred on July 5th which was 24 days earlier than the long term mean. Mean biomass was greatest in early summer months reaching its peak in June and July (Table 11). Shrimp numbers reduced almost 80% by mid-August which is earlier than the long term trend. By October adult densities were low (553 m^2). A high rate of ovigery and high brood numbers were observed in September. Brood numbers are typically highest in October and were not reported this year due to low density of females. Although plankton numbers were sufficient to support populations, early hatching in spring coupled with low summer second generation recruitment likely impacted fall adult *Artemia* numbers. Earlier spring hatching with lower summer recruitment continues a trend observed since 2004. Long-term parameters indicate a slightly below average peak in adult *Artemia* with mean abundance 8% lower than the long term mean.

Changes in Algal Biomass, Adult Density Distribution and Lake Transparency

Lake transparency as measured by Secchi depth was very low throughout the year (<1 m) with an average peak of 1.5 meters in July which was over three times lower than July 2013 (5.08m). June Secchi depths were almost 3 times lower and August almost 7 times lower than 2013 measurements. The greatest Secchi depth for 2014 coincides with the lowest mean epilimnetic density for chlorophyll-a (8.1 µg/L), but was about 6 times greater than July 2013 densities (1.6 µg/L). August mean epilimnetic chorophyll-*a* densities were at least 6 to 8 times greater (24.2 µg/L) than August densities from 2010 to 2013. Secchi depths indicate that Mono Lake was eutrophic and lake transparency did not increase by several meters in summer months as usual. Despite seasonal and inter-year variation, this may be a continuation of a long term trend of increasing epilimnetic chlorophyll *a* concentrations at Mono Lake (Jellison, 2011). Average water temperatures were warmer in all months in 2014 compared to 2013. The greatest difference in average temperatures were observed in the winter (November, December, February, March) and summer months (June - August). During these months average temperatures were about 2°C higher.

Reduced lake levels coupled with warmer water temperatures and readily available nutrients may continue to support high concentrations of algal biomass. Excess algal biomass can result in self shading and increase light attenuation throughout the water column inhibiting photosynthesis by plankton in a reduced euphotic zone. Increased senescence of light limited plankton may result in reduced oxygen availability throughout the water column. In addition to increased biological oxygen demand from vertical mixing this may explain reduced summer epilimnetic DO levels (< 2 mg/L) compared to historical data (Jellison, 1993). Direct measurement of photosynthetically active radiation (PAR) may be beneficial to determine changes in depth of the euphotic zone available for use by phytoplankton.

Sizeable declines in year to year mean adult *Artemia* densities are quite common throughout Mono Lake's monitored history. Historic shifts from meromictic to monmictic cycles also exhibit a marked increase in adult shrimp densities followed by a substantial decrease the following year. Less common, are shorter intervals of high adult density during summer months as occurred in 2014. Mean adult densities were very low during May (832 m^2) and were just above 10,000 m^2 by August. A similar pattern was observed in 2010, with low adult densities in May (1,462 m^2) and moderate numbers by August (11,714 m^2). 2014 continues a trend of larger 1st generations with low summer recruitment and rapid late summer/autumn declines. This general trend has been observed since 2004 and is disadvantageous to migrating Eared Grebes that depend on brine shrimp (Jellison, 2011). Despite shifts in timing of population changes overall brine shrimp abundance remains consistent even since 2004. Brine shrimp reproductive strategies enable them to persist throughout both changing lake mixing regimes and periods of sometimes rapidly changing lake levels. Migratory birds that visit Mono Lake in the summer and early fall are likely to be favored under these conditions.

Appendix:

Summary of Changes in Brine Shrimp Populations in Response to Breakdown of Meromixis

Recent Period of Monomixis and Importance to Biota

The health of *Artemia* populations are linked to primary food sources such as phytoplankton. The main nutrients required by phytoplankton are nitrogen and phosphorous. In Mono Lake nitrogen and its external inputs are limited but phosphorous is abundant. The majority of nitrogen biologically available for direct uptake by phytoplankton is in the form of ammonium. In Mono Lake ammonium is the limiting nutrient for primary productivity and relative contributions from internal nutrient cycling and brine shrimp have been documented (Jellison and Melack 1986, 1988). Ammonium bound in the sediments is made available by internal nutrient recycling driven by changes in thermal and chemical density stratification of Mono Lake. Historically, Mono Lake has shifted between meromictic and monomictic conditions dependent on a multitude of factors including climatic conditions such as temperature, evaporation, wind, freshwater inputs from precipitation and runoff, and exports from diversions. All of these influences affect stratification and mixing dynamics of Mono Lake. Mono Lake exhibited a monomictic mixing regime from 2008-2010, was meromictic in 2011, returned to monomixis in 2012 and remained so in 2013-14. Monomixis, or annual mixing once a year, is important to the nutrient cycle at Mono Lake as it returns nutrients, most importantly, ammonium back to the epilimnion for use by phytoplankton.

Historic Shifting from Meromictic to Monomictic Conditions

Analysis of long term mixing regimes at Mono Lake is important as water column mixing and internal nutrient cycling affect biota including *Artemia* population dynamics. As stated previously the most recent episode of monomixis (2012-2013) marks the 4th time since 1982 that Mono Lake has shifted from a meromictic to a monomictic state. Although vertical mixing does not provide the sole source of ammonium in Mono Lake, it is especially important for primary producers in the spring and fall as contributions from *Artemia* excretions are greatly reduced (Melack, 1988, Jellison and Melack, 1993). *Artemia* populations have fluctuated year to year since LADWP began monitoring Mono Lake in 1982 (see Table 13, Figure 14). Historically *Artemia* abundance has been high in years following the onset of monomixis including 1989, 2004, 2009 and 2013 (Figure 15). Ammonium liberated from anoxic sediments is made biologically available to plankton the fall and winter (1st year of monomixis) previous to years when annual *Artemia* abundance peaks have occurred. Perhaps an abundance of primary production in the year following breakdown of meromixis allow brine shrimp populations to peak the subsequent spring and summer as evidenced by high abundance in those years. Jellison and Rose report high values for primary production in those years following the breakdown of meromixis (2011), although there are occurrences when primary production was high during years of meromixis (Jellison and Rose, 2011). Studies have shown that spring generation brine shrimp raised at high food densities develop more quickly, begin reproducing earlier and that abundance of algae may likely affect year to year changes in shrimp abundance (Jellison and Melack, 1993).

While availability of food sources and nutrients are important they do not fully determine year to year abundance of *Artemia* (subsequent to meromixis). The unique life history of female brine shrimp allow for dormant cysts to stay viable for years. It is known that diapausing cysts require oxygen for hatching (Lenz, 1984). Under meromictic conditions when much of sediment has been anoxic for multiple years a large percentage of cysts likely fail to hatch. When sediments finally become reoxygenated during monomixis dormant cysts may begin to hatch (Jellison et al. 1989). The combination of reoxygenated dormant cyst hatching and mixing of ammonium rich water may likely explain peak years in adult brine shrimp abundance following long periods of meromixis.

Mono Lake Volume and Changes from Fluctuation in Freshwater Inputs

When evaluating the mean surface elevation from 1979 to 2014 a pattern may be emerging between declining lake elevation post meromixis and annual brine shrimp abundance. The greatest mean adult shrimp density documented since 1979 occurred in 1982 when mean annual surface elevation was at the lowest recorded level in the past 34 years (Figure 15, Figure 16). During the preceding years water exports were high resulting in minimal release to Mono Lake (Figure 17). The year 1982 was subsequent to a period of several years of monomixis and was followed by a large release of freshwater in 1983 which set up conditions for a 5 year period of meromixis. The 2nd and 3rd highest mean adult *Artemia* densities occurred in 1989 and 2004 which are years subsequent to the breakdown of meromixis. These were years following below normal runoff years resulting in declining lake levels due to decreased freshwater input. The reduced lake volume combined with reduced fresh water input lessens the thermal and chemical gradient between the upper and lower water column and Mono Lake begins to mix. There may be a long term pattern of population booms during transition periods following the breakdown of meromixis (Figure 15, Figure 16). Despite the benefits from the release and circulation of ammonium rich water during initial years post meromixis, adult brine shrimp populations greatly reduce the following years during both monomictic and meromictic periods. In 2014 there was a 48% decrease of mean adult *Artemia* which is similar to historical second year post meromixis conditions. Mean adult *Artemia* decreased 45% in 1990, 44% in 2005 and 43% in 2010 following year one post-meromictic conditions (Figure 15). Despite year to year fluctuations long term trends for adult *Artemia* abundance continues to be stable.

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Table 1. Secchi Depths (m); February – December 2014.

STATION	SAMPLING DATE 20-Feb	18-Mar	16-Apr	13-May	19-Jun	15-Jul	20-Aug	22-Sep	9-Oct	17-Nov	9-Dec
Western Sector											
1	0.60	0.55	0.50	0.50	0.80	1.60	0.60	0.70	0.50	0.50	0.60
2	0.55	0.50	0.50	0.45	0.90	1.70	0.60	0.50	0.50	0.55	0.50
3	0.50	0.55	0.45	0.45	0.80	1.40	0.60	0.60	0.40	0.50	0.50
4	0.60	0.45	0.50	0.45	0.75	1.30	0.60	0.45	0.50	0.45	0.60
5	0.65	0.50	0.45	0.50	0.80	1.60	0.70	0.50	0.50	0.55	0.50
6	0.65	0.45	0.50	0.50	1.00	1.70	0.70	0.50	0.40	0.60	0.50
AVG	0.59	0.50	0.48	0.48	0.84	1.55	0.63	0.54	0.47	0.53	0.53
SE	0.02	0.02	0.01	0.01	0.04	0.07	0.02	0.04	0.02	0.02	0.02
n	6	6	6	6	6	6	6	6	6	6	6
Eastern Sector											
7	0.50	0.40	0.40	0.45	1.00	1.50	0.60	0.50	0.50	0.55	0.65
8	0.45	0.40	0.45	0.50	1.00	1.50	0.70	0.50	0.40	0.55	0.55
9	0.65	0.50	0.45	0.70	0.80	1.40	0.80	0.75	0.50	0.50	0.60
10	0.55	0.55	0.55	0.50	1.00	1.50	0.80	0.50	0.50	0.60	0.70
11	0.50	0.50	0.40	0.55	0.90	1.20	0.90	0.70	0.50	0.55	0.55
12	0.60	0.45	0.45	0.60	0.90	1.60	0.70	0.50	0.40	0.50	0.60
AVG	0.54	0.47	0.45	0.55	0.93	1.45	0.75	0.58	0.47	0.54	0.61
SE	0.03	0.02	0.02	0.04	0.03	0.06	0.04	0.05	0.02	0.02	0.02
n	6	6	6	6	6	6	6	6	6	6	6
Total Lakewide											
AVG	0.57	0.48	0.47	0.51	0.89	1.50	0.69	0.56	0.47	0.53	0.58
SE	0.03	0.02	0.02	0.03	0.04	0.06	0.04	0.04	0.02	0.02	0.03
n	12	12	12	12	12	12	12	12	12	12	12

Table 2. Temperature (°C) at Station 6, February – December 2014.

Depth (m)	**20-Feb**	**18-Mar**	**16-Apr**	**13-May**	**19-Jun**	**15-Jul**	**20-Aug**	**22-Sep**	**9-Oct**	**17-Nov**	**9-Dec**
0	6.4	7.2	14.9	15.2	19.8	24.3	22.2	19.4	16.0	12.4	8.2
1	5.2	5.8	12.1	12.3	18.5	23.4	20.3	17.7	15.4	10.7	8.1
2	4.5	5.6	11.2	11.8	17.8	23.0	19.7	17.6	15.1	10.6	8.2
3	4.1	5.6	10.8	11.4	17.5	22.8	19.6	17.6	15.1	10.5	8.1
4	4.1	5.7	8.8	10.9	17.3	22.7	19.6	17.6	15.0	10.4	8.1
5	4.1	5.7	8.3	10.4	17.2	22.4	19.5	17.6	15.0	10.5	8.1
6	4.1	5.7	7.9	10.2	17.0	21.0	19.5	17.5	15.1	10.5	8.1
7	4.1	5.8	7.7	10.1	17.0	19.7	19.5	17.5	15.1	10.4	8.1
8	4.1	5.6	7.5	10.1	17.0	18.9	19.5	17.6	15.1	10.4	8.1
9	4.1	5.5	6.6	10.0	16.9	18.0	19.5	17.6	15.0	10.4	8.1
10	4.1	5.4	6.4	10.0	14.8	16.5	19.5	17.6	14.7	10.4	8.2
11	4.1	5.3	6.4	9.9	12.2	14.9	18.9	17.6	14.7	10.4	8.1
12	4.1	5.0	6.4	9.7	10.4	13.0	16.9	17.6	14.7	10.4	8.2
13	4.0	4.7	6.2	9.7	9.2	11.0	13.7	17.2	14.7	10.4	8.2
14	4.0	4.5	5.9	8.8	9.1	9.2	11.6	14.1	14.7	10.4	8.2
15	4.0	4.4	5.8	7.4	8.7	8.3	9.2	12.0	14.7	10.4	8.2
16	4.0	4.3	5.6	7.3	7.6	7.6	8.5	9.7	14.7	10.4	8.2
17	4.0	4.3	5.2	6.6	7.0	7.4	8.1	8.6	14.7	10.4	8.2
18	4.0	4.2	4.8	6.3	6.8	6.7	7.9	8.5	10.0	10.4	8.2
19	4.0	4.1	4.7	5.8	6.8	6.6	7.7	8.5	10.0	10.4	8.2
20	4.0	4.0	4.6	5.6	6.6	6.6	7.7	8.5	10.0	10.4	8.1
21	3.8	4.0	4.5	5.5	6.4	6.5	7.5	8.5	10.0	10.4	8.1
22	3.7	4.0	4.4	5.3	6.3	6.4	7.2	8.5	10.0	10.4	8.1
23	3.5	3.9	4.3	5.1	6.1	6.2	7.0	8.5	10.0	10.4	8.1
24	3.5	3.9	4.3	5.0	5.9	6.0	6.9	8.6	10.0	10.4	8.1
25	3.4	3.9	4.2	4.9	5.8	5.9	6.8	7.8	10.0	10.4	8.1
26	3.4	3.8	4.2	4.9	5.6	5.8	6.7	7.7	10.0	10.4	8.0
27	3.4	3.8	4.1	4.8	5.5	5.8	6.6	7.8	9.4	10.4	8.0
28	3.4	3.8	4.1	4.6	5.4	5.7	6.5	7.8	9.3	10.4	8.0
29	3.4	3.7	4.1	4.5	5.3	5.7	6.2	7.8	9.3	10.3	8.0
30	3.4	3.7	4.0	4.5	5.2	5.6	6.0	7.8	9.1	10.3	8.0
31	3.4	3.7	4.0	4.5	5.2	5.5	6.0	7.8	8.7	10.3	8.0
32	3.4	3.6	3.9	4.5	5.1	5.4	6.0	7.8	8.6	10.3	8.0
33	3.4	3.6	3.9	4.5	-	5.4	5.9	7.7	8.6	10.3	8.0
34	3.4	3.6	3.9	4.4	-	5.3	5.9	7.5	8.5	10.3	7.9
35	3.4	3.6	3.9	4.4	-	5.2	5.9	7.6	8.5	10.3	7.9
36	3.4	3.6	3.9	4.4	-	5.2	5.8	7.8	8.7	10.3	7.9
37	3.4	3.6	3.9	4.4	-	5.2	5.8	7.6	8.6	10.3	7.9
38	3.4	3.6	3.9	4.4	-	5.1	5.7	7.6	8.1	10.3	7.9
39	3.4	3.6	3.9	4.3	-	5.1	-	7.3	7.9	10.3	8.1
40	3.5	3.6	3.9	4.3	-	5.1	-	7.2	7.9	10.3	8.1

Table 3. Conductivity (mS/cm $^{-1}$at 25°C) at Station 6, March – September 2014.

Depth (m)	18-Mar	16-Apr	13-May	19-Jun	15-Jul	20-Aug	22-Sep
1	88.0	85.3	85.4	83.7	73.8	79.4	83.5
2	88.0	86.6	85.5	84.2	74.0	79.6	83.5
3	88.0	86.8	85.7	84.5	74.1	79.7	83.5
4	87.9	87.0	85.6	84.6	77.2	79.7	83.6
5	87.9	87.0	86.0	84.7	80.0	79.7	83.6
6	88.0	86.8	86.0	84.7	81.2	79.7	83.5
7	88.2	87.9	86.0	84.5	83.8	79.6	83.4
8	88.2	87.7	86.0	84.4	84.9	79.9	83.5
9	88.3	87.7	86.0	85.6	84.7	81.9	83.5
10	88.7	87.8	86.0	86.5	85.0	84.6	83.5
11	88.9	87.8	85.4	86.8	85.8	85.6	86.0
12	89.1	88.2	86.9	86.9	86.6	85.8	85.9
13	89.1	88.0	87.3	87.4	87.7	86.8	85.2
14	89.2	88.5	87.4	87.8	87.6	87.5	86.4
15	89.3	88.8	87.3	87.6	87.5	87.3	87.4
16	89.5	89.0	87.7	87.8	87.7	87.6	87.4
17	89.5	89.1	88.1	87.8	87.9	87.6	87.3
18	89.6	89.2	88.4	87.8	87.9	87.6	87.3
19	89.6	89.2	88.4	87.9	88.0	87.9	87.3
20	89.6	89.2	88.4	88.0	88.0	87.9	87.2
21	89.7	89.4	88.7	88.3	88.0	88.0	87.3
22	89.8	89.4	88.8	88.2	88.2	87.9	87.5
23	89.8	89.4	88.9	88.3	88.3	87.9	87.5
24	89.8	89.5	88.9	88.5	88.4	88.0	87.5
25	89.8	89.5	89.1	88.6	88.4	88.2	87.6
26	89.9	89.6	89.2	88.6	88.5	88.1	87.4
27	89.9	89.6	89.2	88.6	88.4	88.2	87.6
28	89.9	89.6	89.2	88.7	88.5	88.2	87.5
29	90.0	89.6	89.2	88.7	88.5	88.2	87.5
30	90.0	89.6	89.2	88.7	88.7	88.2	87.6
31	90.0	89.6	89.2	88.8	88.6	88.2	87.7
32	90.0	89.6	89.2	88.8	88.6	88.3	87.7
33	90.0	89.6	89.3	88.8	88.6	88.3	87.7
34	90.0	89.7	89.3	88.8	88.7	88.3	87.8
35	-	-	89.3	-	83.9	-	82.5
36	-	-	-	-	-	-	-
37	-	-	-	-	-	-	-
38	-	-	-	-	-	-	-
39	-	-	-	-	-	-	-
40	-	-	-	-	-	-	-

Table 4. Dissolved Oxygen* (mg/l) at Station 6, February – December 2014.

Depth (m)	20-Feb	18-Mar	16-Apr	13-May	19-Jun	15-Jul	20-Aug	22-Sep	9-Oct	17-Nov	9-Dec
1	2.2	1.7	3.7	6.2	0.5	1.1	0.5	2.9	4.1	12.5	4.8
2	2.3	1.7	3.8	6.4	0.6	1.1	0.5	2.4	4.2	16.9	4.7
3	2.4	1.6	3.3	6.2	0.7	1.1	0.4	3.0	4.0	14.6	4.1
4	2.4	1.5	2.9	5.7	0.7	1.1	0.4	1.5	3.4	8.4	4.1
5	2.4	1.1	2.3	5.4	0.7	1.1	0.4	2.3	2.4	6.6	4.1
6	2.3	1.0	1.9	5.1	0.7	1.2	0.4	2.6	2.1	15.5	4.1
7	2.3	0.9	1.7	4.8	0.7	0.9	0.4	2.5	1.7	18.4	3.9
8	2.3	0.8	1.6	4.6	0.8	0.8	0.3	2.3	1.4	12.3	4.0
9	2.3	0.7	1.5	4.5	0.7	0.7	0.3	2.0	1.2	7.7	3.8
10	2.3	0.6	1.3	4.4	0.6	0.6	0.3	1.8	0.8	7.1	3.9
11	2.3	0.5	1.3	4.3	0.3	0.5	0.1	1.4	0.7	4.5	3.8
12	2.3	0.5	1.2	4.2	0.2	0.3	0.2	1.8	0.6	4.2	3.8
13	2.3	0.4	1.1	4.2	0.1	0.3	0.2	1.8	0.5	4.0	3.9
14	2.2	0.4	1.1	4.1	0.1	0.3	0.1	0.5	0.4	3.5	3.8
15	2.2	0.3	1.1	3.6	0.0	0.3	0.1	0.4	0.4	3.6	3.9
16	2.2	0.3	1.0	3.2	0.0	0.3	0.1	0.2	0.4	3.3	3.9
17	2.2	0.3	1.0	2.9	0.0	0.3	0.1	0.1	0.4	3.1	4.0
18	2.2	0.3	0.8	2.7	0.0	0.4	0.1	0.1	0.2	2.8	3.9
19	2.2	0.2	0.8	2.4	0.0	0.4	0.1	0.1	0.2	2.6	3.9
20	2.2	0.2	0.7	2.2	0.0	0.4	0.0	0.1	0.1	2.6	3.9
21	2.2	0.2	0.7	2.0	0.0	0.4	0.0	0.1	0.1	2.7	3.9
22	2.2	0.2	0.7	1.8	0.0	0.4	0.0	0.1	0.1	2.7	4.0
23	2.0	0.2	0.7	1.6	0.0	0.4	0.0	0.1	0.1	2.6	4.1
24	2.0	0.2	0.6	1.5	0.0	0.4	-	0.1	0.1	2.7	4.0
25	1.9	0.2	0.6	1.4	0.0	0.4	-	0.1	0.1	2.6	4.1
26	1.9	0.1	0.6	1.3	0.0	0.3	-	0.1	-	2.6	4.1
27	1.9	0.1	0.6	1.2	0.0	0.3	-	0.1	-	2.1	4.1
28	1.9	0.1	0.6	1.1	0.0	0.3	-	0.1	-	2.3	4.1
29	1.9	0.1	0.6	1.1	0.0	0.3	-	0.1	-	2.3	4.1
30	1.9	0.1	0.5	0.9	0.0	0.3	-	0.1	-	2.5	4.3
31	1.8	0.1	0.5	0.8	0.0	0.3	-	0.1	-	2.4	4.4
32	1.8	0.1	0.5	0.7	0.0	0.3	-	0.1	-	2.5	4.4
33	1.8	0.1	0.5	0.6	0.0	0.3	-	-	-	2.5	4.4
34	1.8	0.1	0.4	0.5	0.0	0.3	-	-	-	2.4	4.3
35	1.8	0.1	0.4	0.5	0.0	0.3	-	-	-	2.3	4.3
36	1.8	0.1	0.4	0.5	0.0	0.3	-	-	-	2.6	4.4
37	1.7	0.1	0.4	0.4	0.0	0.3	-	-	-	2.6	4.5
38	1.7	0.1	0.4	0.4	0.0	0.3	-	-	-	2.5	4.5
39	1.7	0.1	0.4	0.3	0.0	0.3	-	-	-	-	-
40	1.8	0.1	0.4	0.3	0.0	0.3	-	-	-	-	-

*YSI probe error (+/- 0.2 mg/L).

Table 5. Ammonium (µM) at Station 6, February through December 2014.

Depth (m)	20-Feb	18-Mar	16-Apr	13-May	19-Jun	15-Jul	20-Aug	22-Sep	9-Oct	17-Nov	9-Dec
1	-	-	-	-	-	-	-	-	-	-	-
2	2.8	<2.8	<2.8	<2.8	3.3	3.3	<2.8	3.3	2.8	3.9	4.4
3	-	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	-	-	-
8	<2.8	<2.8	<2.8	<2.8	3.3	3.3	3.3	3.9	<2.8	3.9	6.7
9	-	-	-	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	-	-	-
11	-	-	-	-	-	-	-	-	-	-	-
12	<2.8	<2.8	<2.8	<2.8	3.9	5.0	6.1	3.3	3.9	3.3	5.0
13	-	-	-	-	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-	-	-	-
15	-	-	-	-	-	-	-	-	-	-	-
16	<2.8	<2.8	<2.8	<2.8	6.7	10.0	17.7	14.4	3.9	3.3	3.9
17	-	-	-	-	-	-	-	-	-	-	-
18	-	-	-	-	-	-	-	-	-	-	-
19	-	-	-	-	-	-	-	-	-	-	-
20	<2.8	<2.8	3.3	3.9	8.9	14.4	22.7	21.6	17.7	3.3	3.3
21	-	-	-	-	-	-	-	-	-	-	-
22	-	-	-	-	-	-	-	-	-	-	-
23	-	-	-	-	-	-	-	-	-	-	-
24	<2.8	<2.8	4.4	6.7	10.0	14.4	27.2	18.3	18.8	3.3	3.9
25	-	-	-	-	-	-	-	-	-	-	-
26	-	-	-	-	-	-	-	-	-	-	-
27	-	-	-	-	-	-	-	-	-	-	-
28	<2.8	2.8	5.5	7.8	11.1	17.2	27.2	27.7	21.6	3.3	3.9

Laboratory detection limit of 2.8µm.

Table 6. 9-meter integrated values for Ammonium (µm) – February to December 2014.

Station	20-Feb	18-Mar	16-Apr	13-May	19-Jun	15-Jul	20-Aug	22-Sep	9-Oct	17-Nov	9-Dec
1	<2.8	<2.8	<2.8	<2.8	3.3	<2.8	<2.8	<2.8	3.3	2.8	3.3
2	<2.8	<2.8	<2.8	<2.8	<2.8	3.3	<2.8	<2.8	2.8	3.3	4.4
5	<2.8	2.8	<2.8	<2.8	<2.8	3.3	3.3	3.3	<2.8	3.9	<2.8
6	2.8	<2.8	<2.8	<2.8	3.3	3.3	<2.8	3.3	<2.8	3.9	4.4
7	2.8	<2.8	3.3	<2.8	<2.8	2.8	<2.8	<2.8	<2.8	2.8	2.8
8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	3.3	<2.8	<2.8	3.3	2.8
11	<2.8	2.8	<2.8	<2.8	<2.8	3.3	<2.8	<2.8	<2.8	5.0	3.3
Mean	2.8	2.8	3.3	2.8	3.3	3.2	3.3	3.3	3.1	3.6	3.5
SE	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.00	0.25	0.29	0.28

Laboratory detection limit of 2.8µm.

Table 7. Chlorophyll *a* (µg /l) at Station 6 – February through December 2014.

Depth (m)	20-Feb	18-Mar	16-Apr	13-May	19-Jun	15-Jul	20-Aug	22-Sep	9-Oct	17-Nov	9-Dec
1	-	-	-	-	-	-	-	-	-	-	-
2	53.0	56.4	57.2	33.1	11.8	5.4	28.8	52.0	75.6	95.7	88.2
3	-	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	-	-	-
8	54.6	54.2	57.2	28.7	14.3	13.3	27.3	52.2	70.2	88.7	98.9
9	-	-	-	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	-	-	-
11	-	-	-	-	-	-	-	-	-	-	-
12	53.0	51.9	66.9	36.0	39.7	48.3	47.7	51.1	67.0	91.7	99.0
13	-	-	-	-	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-	-	-	-
15	-	-	-	-	-	-	-	-	-	-	-
16	56.7	54.0	59.8	43.1	54.9	71.1	80.5	73.2	74.7	92.8	97.9
17	-	-	-	-	-	-	-	-	-	-	-
18	-	-	-	-	-	-	-	-	-	-	-
19	-	-	-	-	-	-	-	-	-	-	-
20	65.3	53.4	57.5	47.4	49.8	77.2	84.2	82.1	75.2	64.7	92.3
21	-	-	-	-	-	-	-	-	-	-	-
22	-	-	-	-	-	-	-	-	-	-	-
23	-	-	-	-	-	-	-	-	-	-	-
24	71.8	57.7	59.5	44.0	66.2	71.1	88.9	69.8	65.7	94.0	96.8
25	-	-	-	-	-	-	-	-	-	-	-
26	-	-	-	-	-	-	-	-	-	-	-
27	-	-	-	-	-	-	-	-	-	-	-
28	70.7	62.1	59.0	48.0	68.5	78.7	92.8	74.1	63.7	96.4	97.5

Table 8. 9-meter integrated values for chlorophyll *a* (µg/l) – February to December 2014.

Station	20-Feb	18-Mar	16-Apr	13-May	19-Jun	15-Jul	20-Aug	22-Sep	9-Oct	17-Nov	9-Dec
1	52.1	52.2	57.3	27.3	17.7	9.7	28.5	45.9	67.1	81.7	94.5
2	59.9	51.1	53.8	35.9	17.2	9.3	23.3	45.7	70.2	90.1	95.3
5	52.9	51.8	54.8	26.9	15.2	7.1	29.8	54.0	72.3	90.7	96.9
6	54.6	47.3	52.7	31.9	9.2	3.9	24.6	52.5	69.3	93.5	95.1
7	61.8	61.5	60.2	29.8	13.4	10.3	19.6	51.1	56.4	89.6	97.3
8	64.9	55.4	53.9	33.0	12.3	9.8	24.1	53.3	59.1	92.3	99.8
11	57.8	50.2	48.0	34.3	11.0	9.6	19.5	53.9	58.7	68.1	105.1
Mean	57.7	52.8	54.4	31.3	13.7	8.1	24.2	50.9	64.7	86.6	97.7
SE	1.69	1.72	1.43	1.31	1.20	0.86	1.49	1.37	2.45	3.39	1.41

Table 9a. *Artemia* lake and sector means, 2014

	Instars					Ad Female Ovigery Classification				
	1-7	8-11	Adult Total	Adult Males	Adult Female Total	empty	undif	cysts	naup	Total *Artemia*
Lakewide mean										
20-Feb	35,352	88	6	0	6	6	0	0	0	35,447
18-Mar	150,909	214	0	0	0	0	0	0	0	151,123
16-Apr	119,732	27	0	0	0	0	0	0	0	119,759
13-May	60,416	74,017	832	751	80	54	0	27	0	135,265
19-Jun	3,783	35,359	33,535	25,701	7,834	1,315	832	4,802	885	72,676
15-Jul	555	13,032	42,298	26,568	15,729	1,462	2,420	10,007	1,840	55,884
20-Aug	712	268	10,776	5,747	5,029	208	192	4,033	596	11,756
22-Sep	476	121	4,019	1,988	2,031	44	68	1,777	142	4,616
9-Oct	521	161	553	329	224	8	8	184	24	1,235
17-Nov	44	32	106	69	36	3	9	17	6	181
9-Dec	148	19	66	47	19	2	3	6	8	233
Western Sector mean										
20-Feb	44,201	227	0	0	0	0	0	0	0	44,428
18-Mar	23,072	25	13	0	13	13	0	0	0	23,109
16-Apr	64,333	54	0	0	0	0	0	0	0	64,386
13-May	41,851	45,553	1,019	858	161	107	0	54	0	88,424
19-Jun	2,414	37,773	30,047	23,555	6,492	858	858	4,078	698	70,235
15-Jul	807	13,713	44,163	27,577	16,586	1,916	2,924	9,629	2,117	58,682
20-Aug	693	132	7,297	3,995	3,302	113	107	2,659	422	8,123
22-Sep	369	91	2,341	1,141	1,200	28	47	1,021	104	2,801
9-Oct	321	95	340	199	142	13	9	110	9	756
17-Nov	9	9	47	28	19	0	6	9	3	66
9-Dec	69	3	32	22	9	0	0	6	3	104
Eastern Sector mean										
20-Feb	257,617	202	0	0	0	0	0	0	0	257,819
18-Mar	47,633	151	0	0	0	0	0	0	0	47,785
16-Apr	175,131	0	0	0	0	0	0	0	0	175,131
13-May	78,981	102,482	644	644	0	0	0	0	0	182,106
19-Jun	5,151	32,944	37,022	27,847	9,175	1,771	805	5,526	1,073	75,117
15-Jul	302	12,352	40,432	25,560	14,872	1,008	1,916	10,385	1,563	53,086
20-Aug	731	403	14,255	7,499	6,756	302	277	5,407	769	15,389
22-Sep	583	151	5,697	2,836	2,861	60	88	2,533	180	6,431
9-Oct	722	227	766	460	306	3	6	258	38	1,714
17-Nov	79	54	164	110	54	6	13	25	9	296
9-Dec	227	35	101	72	28	3	6	6	13	362

Table 9b. Standard errors of *Artemia* sector means (from Table 9a), 2014.

	Instars					Ad Female Ovigery Classification				
	1-7	8-11	Adult Total	Adult Males	Adult Female Total	empty	undif	cysts	naup	Total *Artemia*
SE of Lakewide mean										
20-Feb	4,624	76	6	0	6	6	0	0	0	4,629
18-Mar	47,129	135	0	0	0	0	0	0	0	47,131
16-Apr	26,553	27	0	0	0	0	0	0	0	26,551
13-May	8,885	11,460	258	270	58	54	0	27	0	19,454
19-Jun	613	3,584	2,981	2,165	1,045	219	151	811	248	6,220
15-Jul	148	1,825	4,128	2,367	1,962	316	605	950	346	5,765
20-Aug	136	62	1,839	1,026	848	70	40	677	114	1,930
22-Sep	76	26	970	485	491	18	24	415	53	1,042
9-Oct	135	39	111	69	45	4	3	39	8	269
17-Nov	13	12	31	22	11	2	3	7	4	54
9-Dec	40	8	28	20	9	2	3	4	4	71
SE of Western Sector mean										
20-Feb	16,502	198	0	0	0	0	0	0	0	16,650
18-Mar	4,168	25	13	0	13	13	0	0	0	4,161
16-Apr	12,064	54	0	0	0	0	0	0	0	12,092
13-May	5,773	12,354	473	510	110	107	0	54	0	16,069
19-Jun	517	5,851	3,271	2,546	1,384	271	245	894	316	8,780
15-Jul	243	3,671	8,242	4,711	3,569	510	1,123	1,592	530	11,717
20-Aug	182	67	2,323	1,442	895	39	27	778	113	2,499
22-Sep	55	39	368	187	201	12	16	155	27	434
9-Oct	72	23	85	55	34	6	4	30	4	159
17-Nov	4	4	14	11	7	0	4	6	3	17
9-Dec	21	3	21	12	9	0	0	6	3	37
SE Eastern Sector Mean										
20-Feb	70,328	202	0	0	0	0	0	0	0	70,308
18-Mar	4,046	151	0	0	0	0	0	0	0	4,012
16-Apr	41,582	0	0	0	0	0	0	0	0	41,582
13-May	13,273	10,058	235	235	0	0	0	0	0	23,009
19-Jun	797	4,468	4,852	3,507	1,472	231	199	1,372	396	9,525
15-Jul	110	995	2,376	1,431	1,978	309	498	1,176	465	2,411
20-Aug	219	72	2,155	1,150	1,082	128	57	810	179	2,207
22-Sep	133	32	1,698	845	862	35	45	712	105	1,810
9-Oct	243	65	171	104	71	3	4	60	15	448
17-Nov	14	21	52	37	18	4	4	12	6	85
9-Dec	63	13	50	37	14	3	6	4	6	120

Table 9c. Percentage in different classes for *Artemia* sector means (from Table 9a), 2014.

	Instars		Instar %	Adult Total	Adult Males	Adult Female Total	Ad Female Ovigery Classification				Ovigerous Female%
	1-7	8-11					empty	undif	cysts	naup	
Lakewide %											
20-Feb	99.7	0.2	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18-Mar	99.9	0.1	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16-Apr	100.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13-May	44.7	54.7	99.4	0.6	0.6	0.1	66.7	0.0	0.0	0.0	0.0
19-Jun	5.2	48.7	53.9	46.1	35.4	10.8	16.8	10.6	61.3	11.3	83.2
15-Jul	1.0	23.3	24.3	75.7	47.5	28.1	9.3	15.4	63.6	11.7	90.7
20-Aug	6.1	2.3	8.3	91.7	48.9	42.8	4.1	3.8	80.2	11.8	95.9
22-Sep	10.3	2.6	12.9	87.1	43.1	44.0	2.2	3.3	87.5	7.0	97.8
9-Oct	42.2	13.0	55.2	44.8	26.7	18.1	3.5	3.5	82.4	10.6	96.5
17-Nov	24.3	17.4	41.7	58.3	38.3	20.0	8.7	26.1	47.8	16.7	90.6
9-Dec	63.5	8.1	71.6	28.4	20.3	8.1	8.3	16.7	33.3	41.7	91.7
Western Sector %											
20-Feb	99.5	0.5	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18-Mar	99.8	0.1	99.9	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0
16-Apr	99.9	0.1	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13-May	47.3	51.5	98.8	1.2	1.0	0.2	66.7	0.0	0.0	0.0	0.0
19-Jun	3.4	53.8	57.2	42.8	33.5	9.2	13.2	13.2	62.8	10.7	86.8
15-Jul	1.4	23.4	24.7	75.3	47.0	28.3	11.6	17.6	58.1	12.8	88.4
20-Aug	8.5	1.6	10.2	89.8	49.2	40.7	3.4	3.2	80.5	12.8	96.6
22-Sep	13.2	3.3	16.4	83.6	40.7	42.9	2.4	3.9	85.0	8.7	97.6
9-Oct	42.5	12.5	55.0	45.0	26.3	18.8	8.9	6.7	77.8	6.7	91.1
17-Nov	14.3	14.3	28.6	71.4	42.9	28.6	0.0	33.3	50.0	16.7	100.0
9-Dec	66.7	3.0	69.7	30.3	21.2	9.1	0.0	0.0	0.0	0.0	0.0
Eastern Sector %											
20-Feb	99.9	0.1	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18-Mar	99.7	0.3	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16-Apr	100.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13-May	43.4	56.3	99.6	0.4	0.4	0.0	0.0	0.0	0.0	0.0	0.0
19-Jun	6.9	43.9	50.7	49.3	37.1	12.2	19.3	8.8	60.2	11.7	80.7
15-Jul	0.6	23.3	23.8	76.2	48.1	28.0	6.8	12.9	69.8	0.0	82.7
20-Aug	4.8	2.6	7.4	92.6	48.7	43.9	4.5	4.1	80.0	11.4	95.5
22-Sep	9.1	2.4	11.4	88.6	44.1	44.5	2.1	3.1	88.5	0.0	91.6
9-Oct	42.1	13.2	55.3	44.7	26.8	17.8	1.0	2.1	84.5	0.0	86.6
17-Nov	26.6	18.1	44.7	55.3	37.2	18.1	11.8	23.5	47.1	20.0	90.6
9-Dec	62.6	9.6	72.2	27.8	20.0	7.8	11.1	22.2	22.2	44.4	88.9

Table 10. Lakewide *Artemia* instar analysis, 2014.

	Instars									
	1	2	3	4	5	6	7	8-11	Adults	Total
Mean:										
20-Feb	34094	508	0	0	0	0	86	0	11	34699
18-Mar	46626	116814	3371	0	0	0	0	173	0	166983
16-Apr	5427	48198	15499	15223	5151	3909	1196	0	0	94602
13-May	1380	10026	7450	11498	7450	9566	11773	77540	920	137603
19-Jun	598	1380	230	184	0	276	736	38034	34033	75470
15-Jul	130	346	0	0	0	0	0	14217	48009	62701
20-Aug	27	265	130	38	5	38	22	265	10895	11684
22-Sep	59	151	81	51	73	30	27	113	4505	5091
9-Oct	49	173	68	105	59	57	127	162	608	1407
17-Nov	3	14	0	0	3	5	5	16	76	122
9-Dec	59	43	8	14	0	3	22	16	59	224
Standard error of the mean:										
20-Feb	16443	57826	1260	0	0	0	0	173	0	74683
18-Mar	6655	201	0	0	0	0	86	0	11	6632
16-Apr	1638	8580	4109	8048	3228	2810	893	0	0	24274
13-May	569	2457	418	3641	2162	1629	1961	13161	441	20078
19-Jun	191	582	182	119	0	178	250	5686	3828	8832
15-Jul	90	167	0	0	0	0	0	2920	5971	8715
20-Aug	18	98	62	18	5	22	11	88	2803	2916
22-Sep	41	50	20	15	16	12	21	29	1664	1787
9-Oct	27	27	21	39	26	29	70	53	1664	1787
17-Nov	3	5	0	0	3	3	3	8	18	32
9-Dec	25	17	4	9	0	3	16	13	47	123
Percentage in different age classes:										
20-Feb	27.9	70.0	2.0	0.0	0.0	0.0	0.0	0.1	0.0	100.0
18-Mar	98.3	1.5	0.0	0.0	0.0	0.0	0.2	0.0	0.0	100.0
16-Apr	5.7	50.9	16.4	16.1	5.4	4.1	1.3	0.0	0.0	100.0
13-May	1.0	7.3	5.4	8.4	5.4	7.0	8.6	56.4	0.7	100.0
19-Jun	0.8	1.8	0.3	0.2	0.0	0.4	1.0	50.4	45.1	100.0
15-Jul	0.2	0.6	0.0	0.0	0.0	0.0	0.0	22.7	76.6	100.0
20-Aug	0.2	2.3	1.1	0.3	0.0	0.3	0.2	2.3	93.3	100.0
22-Sep	1.2	3.0	1.6	1.0	1.4	0.6	0.5	2.2	88.5	100.0
9-Oct	3.5	12.3	4.8	7.5	4.2	4.0	9.0	11.5	43.2	100.0
17-Nov	2.2	11.1	0.0	0.0	2.2	4.4	4.4	13.3	62.2	100.0
9-Dec	26.5	19.3	3.6	6.0	0.0	1.2	9.6	7.2	26.5	100.0

Table 11. *Artemia* biomass summary, 2014.

	Mean Biomass		
Date	Lakewide	Western Sector	Eastern Sector
20-Feb	1.40	0.97	1.82
18-Mar	3.83	1.20	6.45
16-Apr	3.88	1.98	5.78
13-May	17.1	10.1	24.0
19-Jun	28.7	24.4	33.1
15-Jul	28.2	30.1	26.2
20-Aug	7.68	5.33	10.0
22-Sep	5.08	3.76	6.40
9-Oct	0.90	0.72	1.07
17-Nov	0.49	0.47	0.50
9-Dec	0.21	0.14	0.27

Table 12. *Artemia* fecundity summary, 2014.

	#eggs/brood		%cysts	%indented	Female Length	
	mean	SE			Mean	SE
Lakewide Mean:						
19-Jun	24.3	0.82	94%	49%	9.3	0.16
15-Jul	18.3	0.50	99%	71%	8.1	0.22
20-Aug	31.7	1.91	99%	53%	8.8	0.17
22-Sep	67.5	2.43	97%	59%	9.7	0.12
Western Sector Mean:						
19-Jun	25.0	1.25	51%	30%	9.2	0.27
15-Jul	19.2	0.70	56%	37%	7.9	0.37
20-Aug	31.7	2.73	56%	30%	8.6	0.26
22-Sep	68.8	3.79	56%	36%	9.6	0.16
Eastern Sector Mean:						
19-Jun	23.5	0.96	43%	19%	9.4	0.14
15-Jul	17.1	0.65	43%	34%	8.5	0.13
20-Aug	31.7	2.66	43%	23%	9.1	0.17
22-Sep	65.9	2.61	41%	23%	9.9	0.17

Table 13. Summary Statistics of Adult *Artemia* Abundance from 1 May through 30 November, 1979-2014.

Year	Mean	Median	Peak	Centroid
1979	14,118	12,286	31,700	216
1980	14,643	10,202	40,420	236
1981	32,010	21,103	101,670	238
1982	36,643	31,457	105,245	252
1983	17,812	16,314	39,917	247
1984	17,001	19,261	40,204	212
1985	18,514	20,231	33,089	218
1986	14,667	17,305	32,977	190
1987	23,952	22,621	54,278	226
1988	27,639	25,505	71,630	207
1989	36,359	28,962	92,491	249
1990	20,005	16,775	34,930	230
1991	18,129	19,319	34,565	226
1992	19,019	19,595	34,648	215
1993	15,025	16,684	26,906	217
1994	16,602	18,816	29,408	212
1995	15,584	17,215	24,402	210
1996	17,734	17,842	34,616	216
1997	14,389	16,372	27,312	204
1998	19,429	21,235	33,968	226
1999	20,221	21,547	38,439	225
2000	10,550	9,080	22,384	210
2001	20,031	20,037	38,035	209
2002	11,569	9,955	25,533	200
2003	13,778	12,313	29,142	203
2004	32,044	36,909	75,466	180
2005	17,888	15,824	45,419	192
2006	21,518	20,316	55,748	186
2007	18,826	17,652	41,751	186
2008	11,823	12,524	27,606	189
2009	25,970	17,919	72,086	181
2010	14,921	7,447	46,237	191
2011	21,343	16,893	48,918	194
2012	16,324	11,302	53,813	179
2013	26,033	31,275	54,347	196
2014	13,467	7,602	42,298	186
Mean	19,599	18,269	45,600	210
Min	10,550	7,447	22,384	179
Max	36,643	36,909	105,245	252

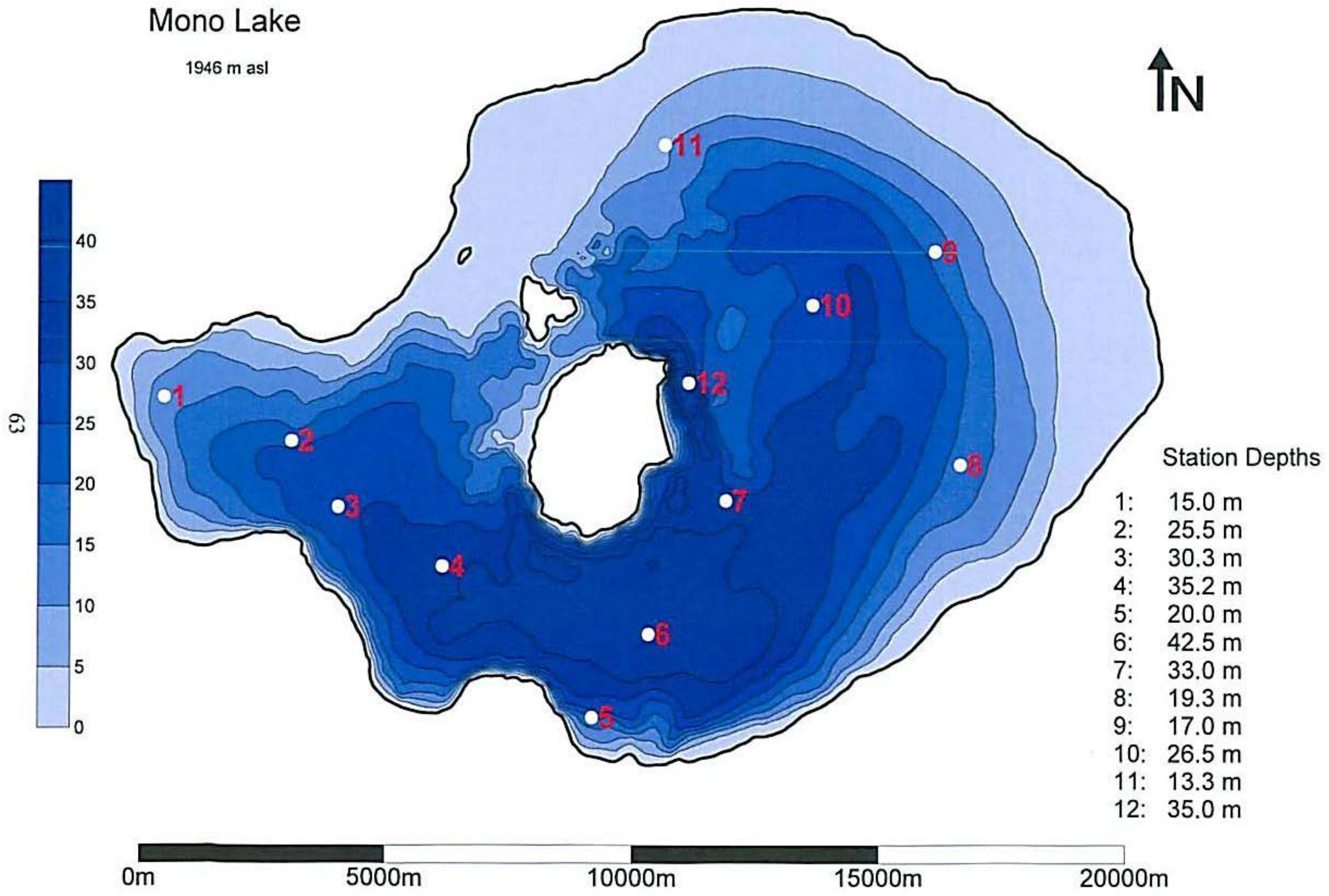

Figure 1. Sampling Stations at Mono Lake and Associated Station Depths.

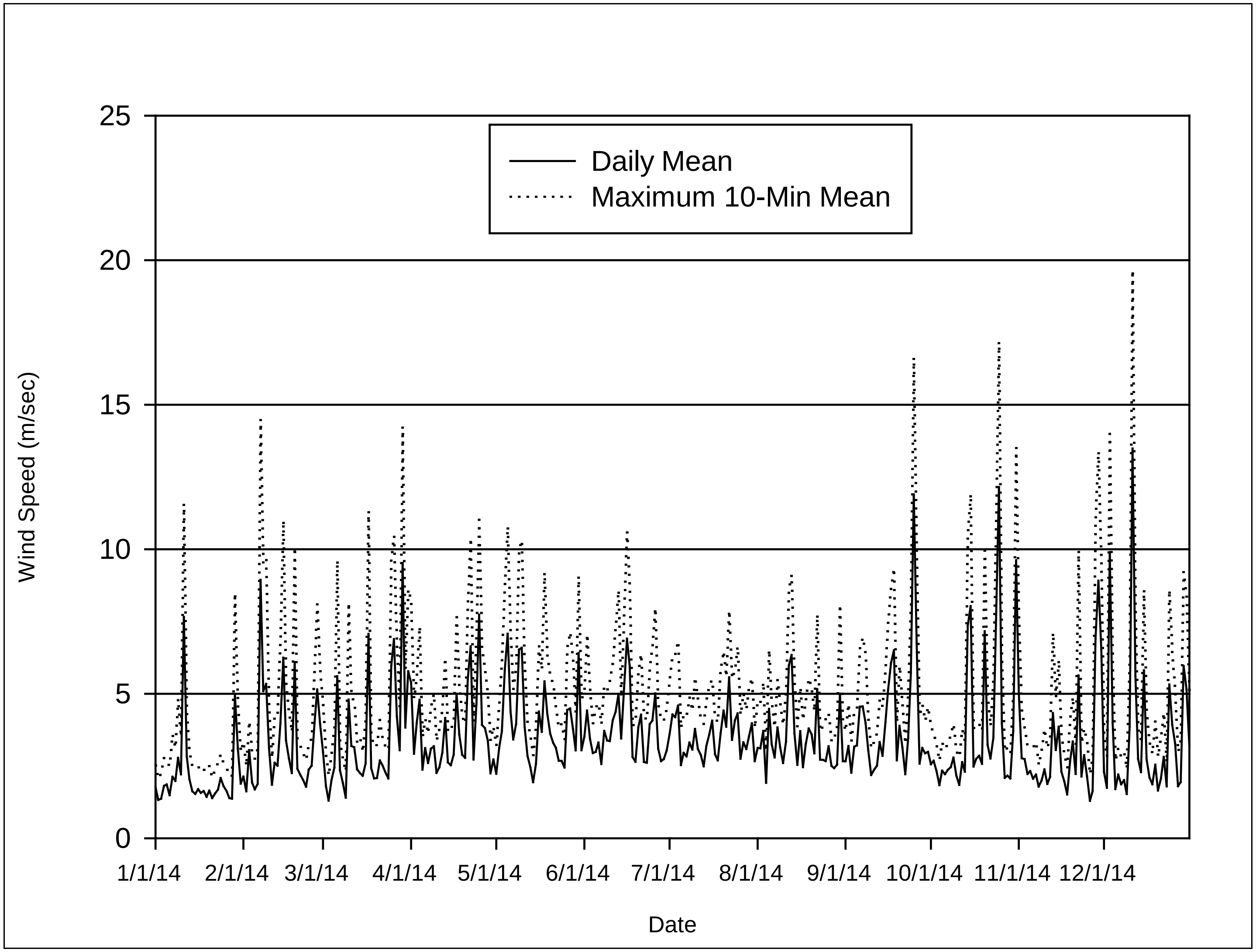

Figure 2. Mean daily wind speed and mean maximum 10-minute wind speed Paoha Island, January 1st - December 31st, 2014.

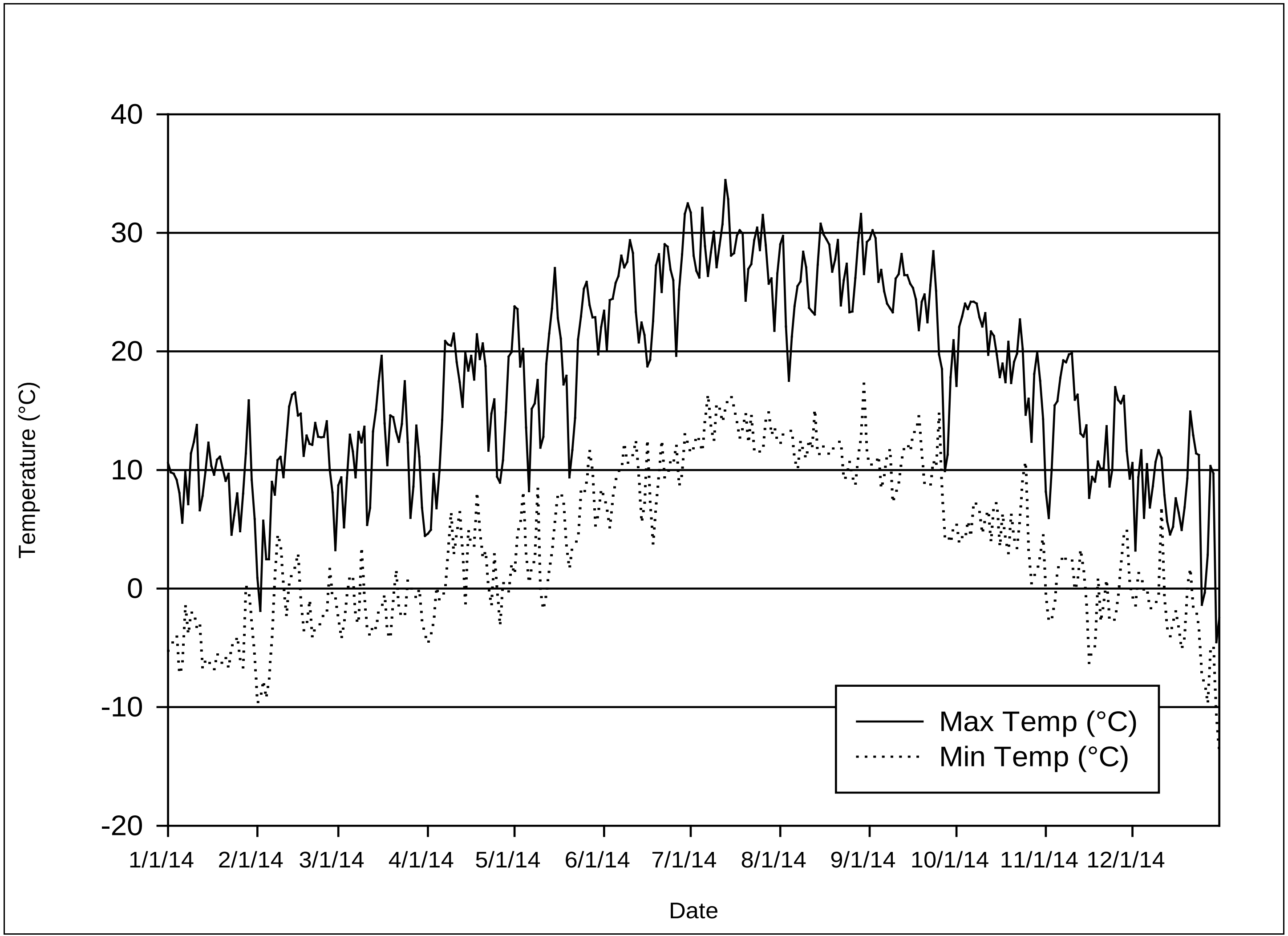

Figure 3. Minimum and maximum daily temperature (°C) as recorded at Paoha Island, January 1st - December 31st, 2014.

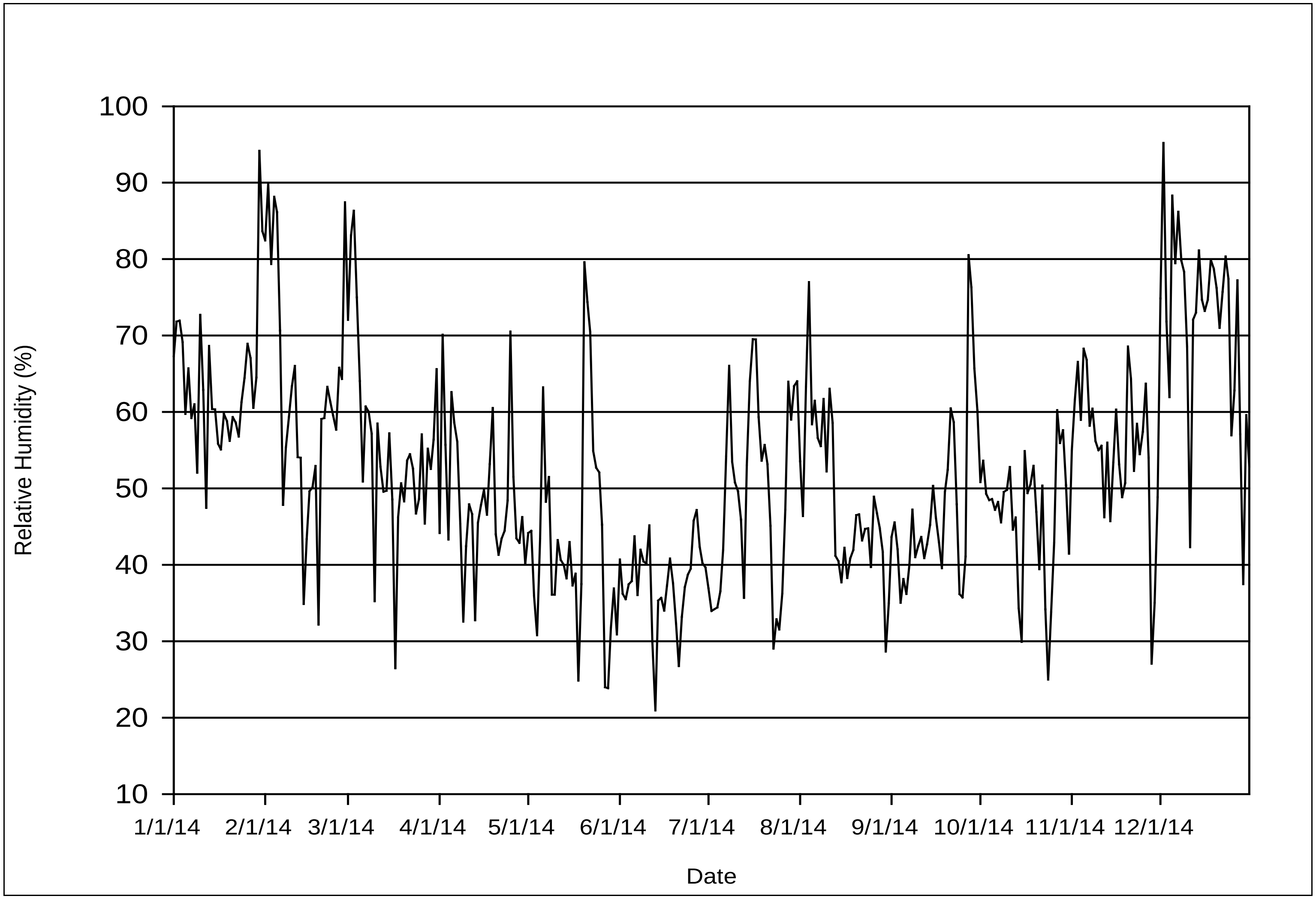

Figure 4. Mean relative humidity (%) – Paoha Island, January 1st - December 31st, 2014.

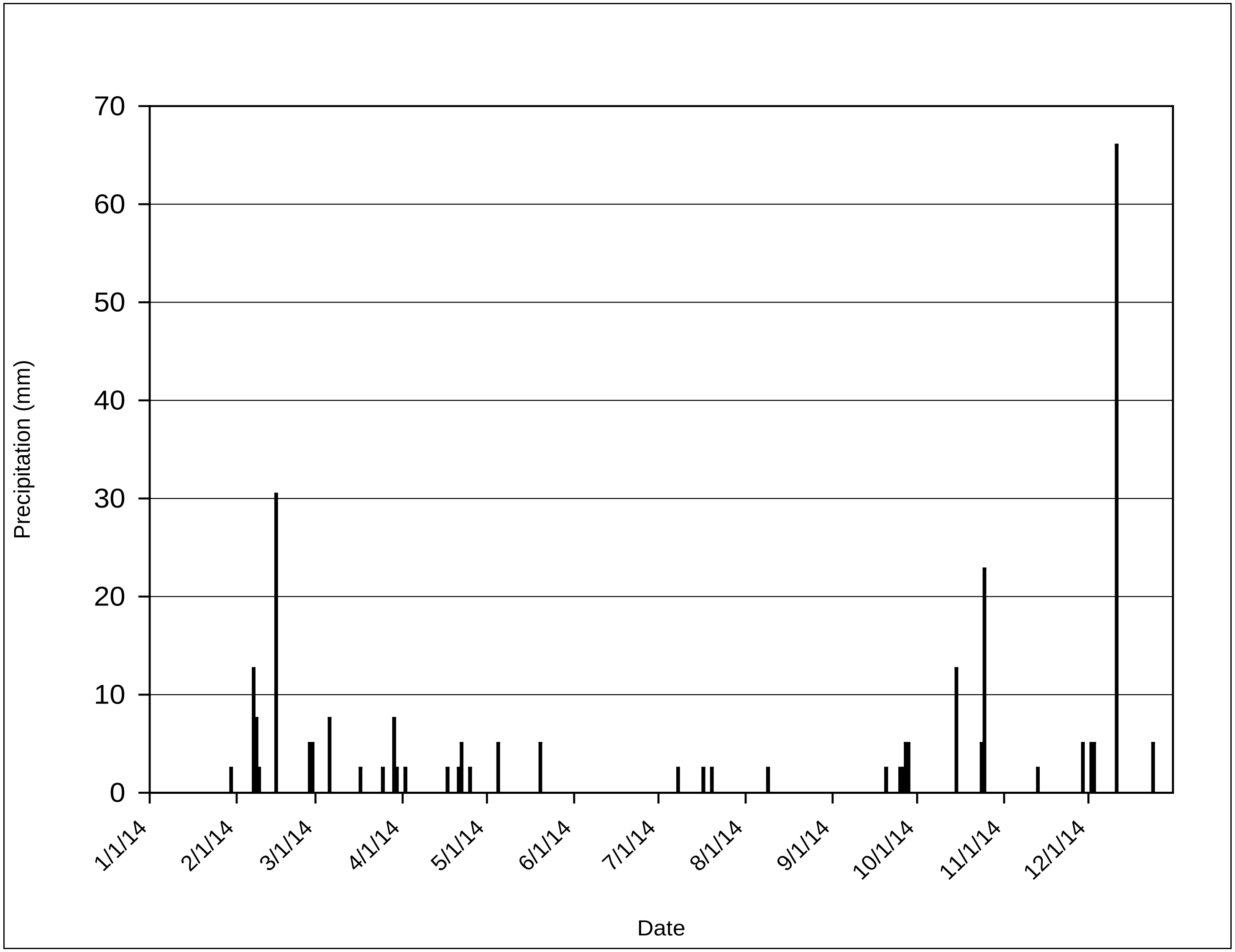

Figure 5. Precipitation (mm) at Paoha Island, Mono Lake, 2014.

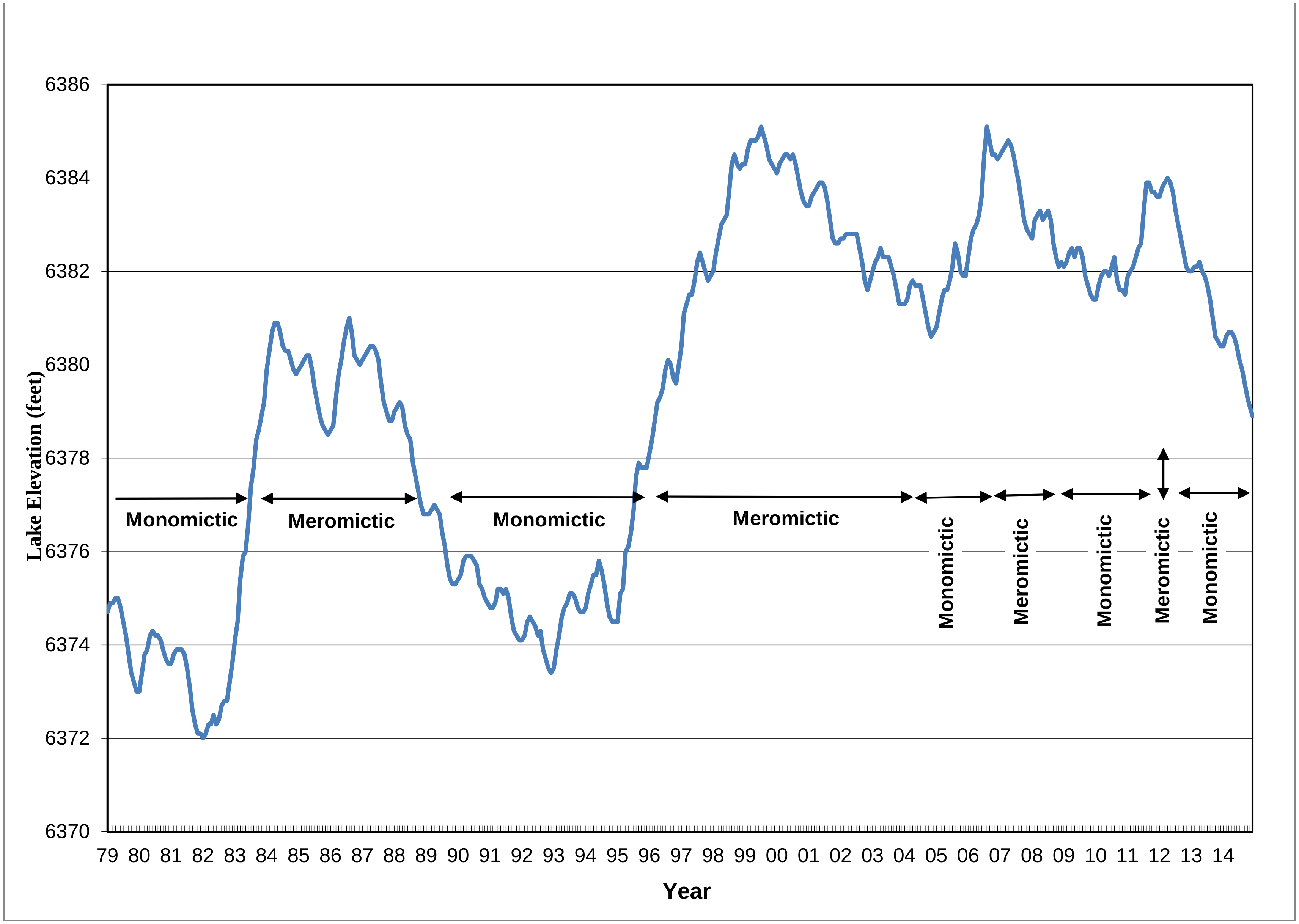

Figure 6. Surface elevation of Mono Lake and mixing regime, 1979-2014 (data ends on calendar year).

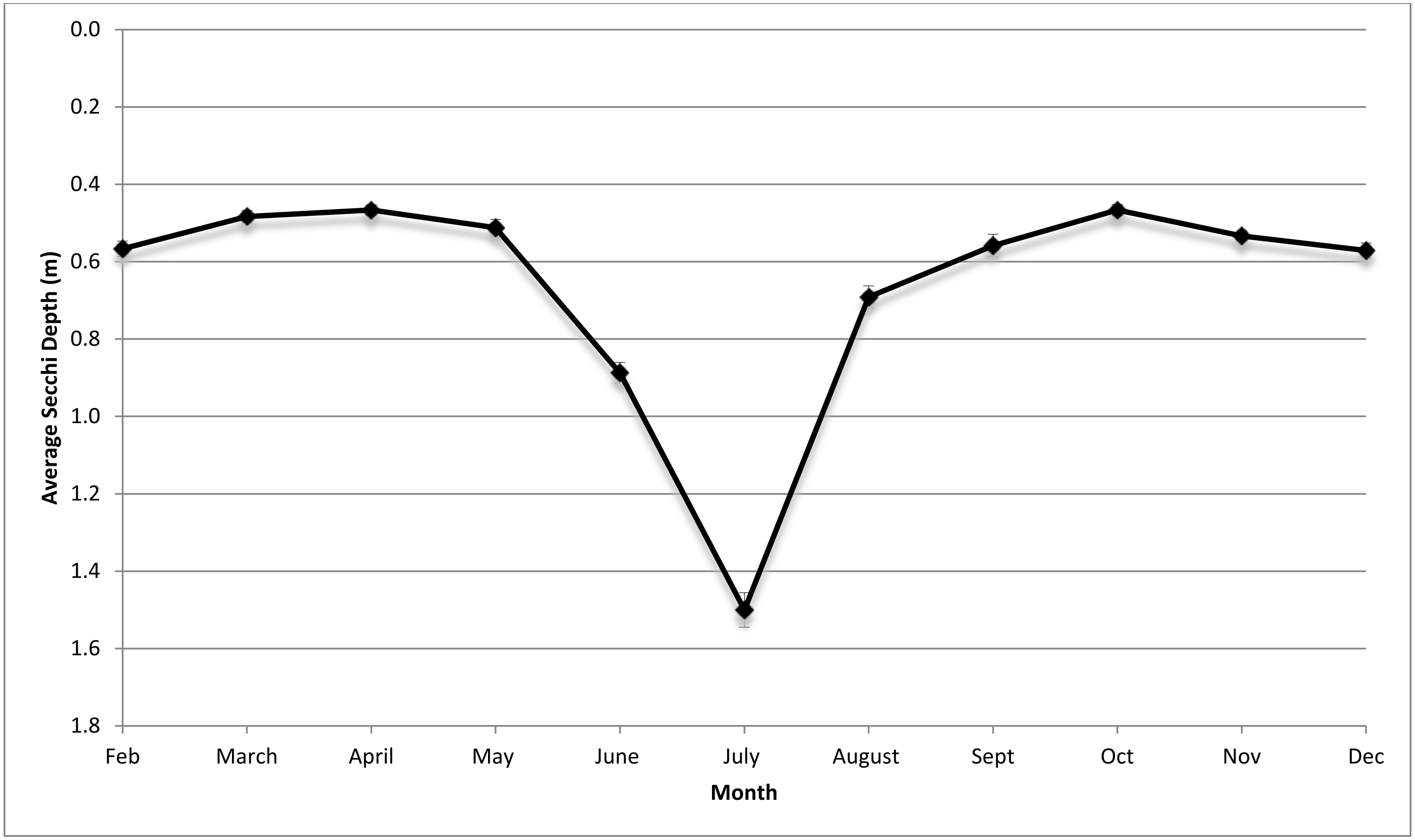

Figure 7. Secchi depths (meters) and standard error, 2014.

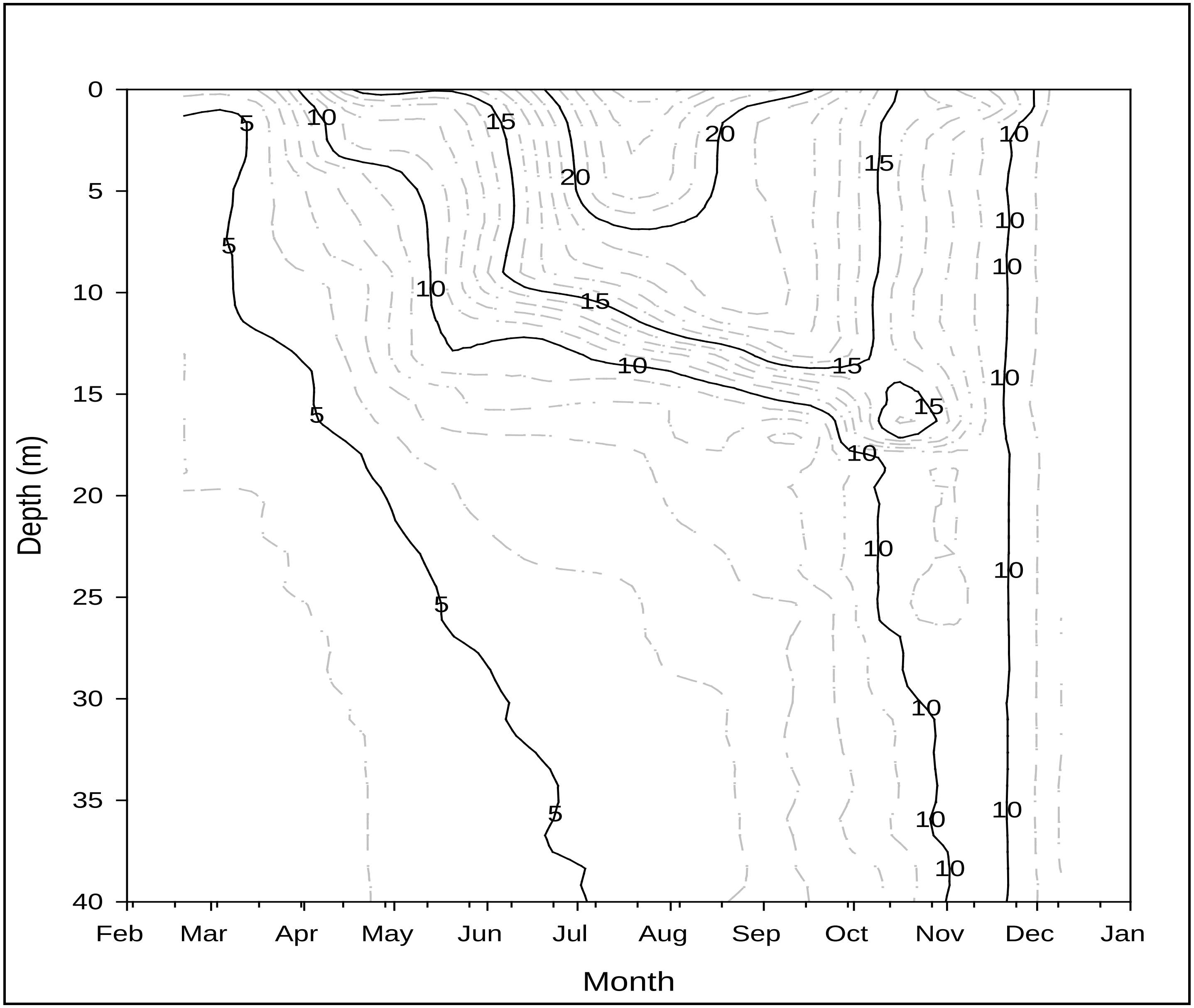

Figure 8. Temperature profiles at Station 6, February to December 2014.

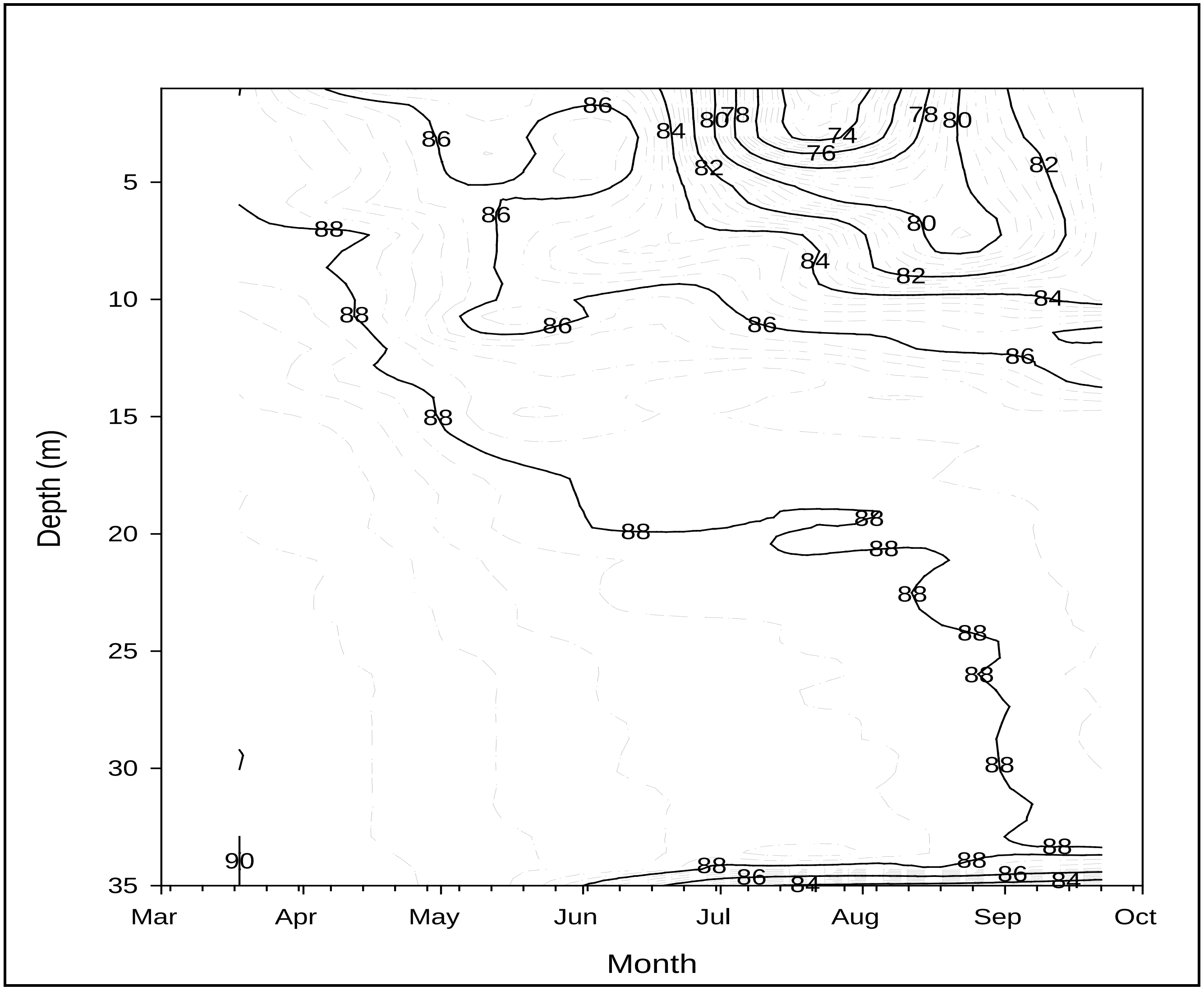

Figure 9. Conductivity (mS/cm) profiles at Station 6, March-September, 2014.

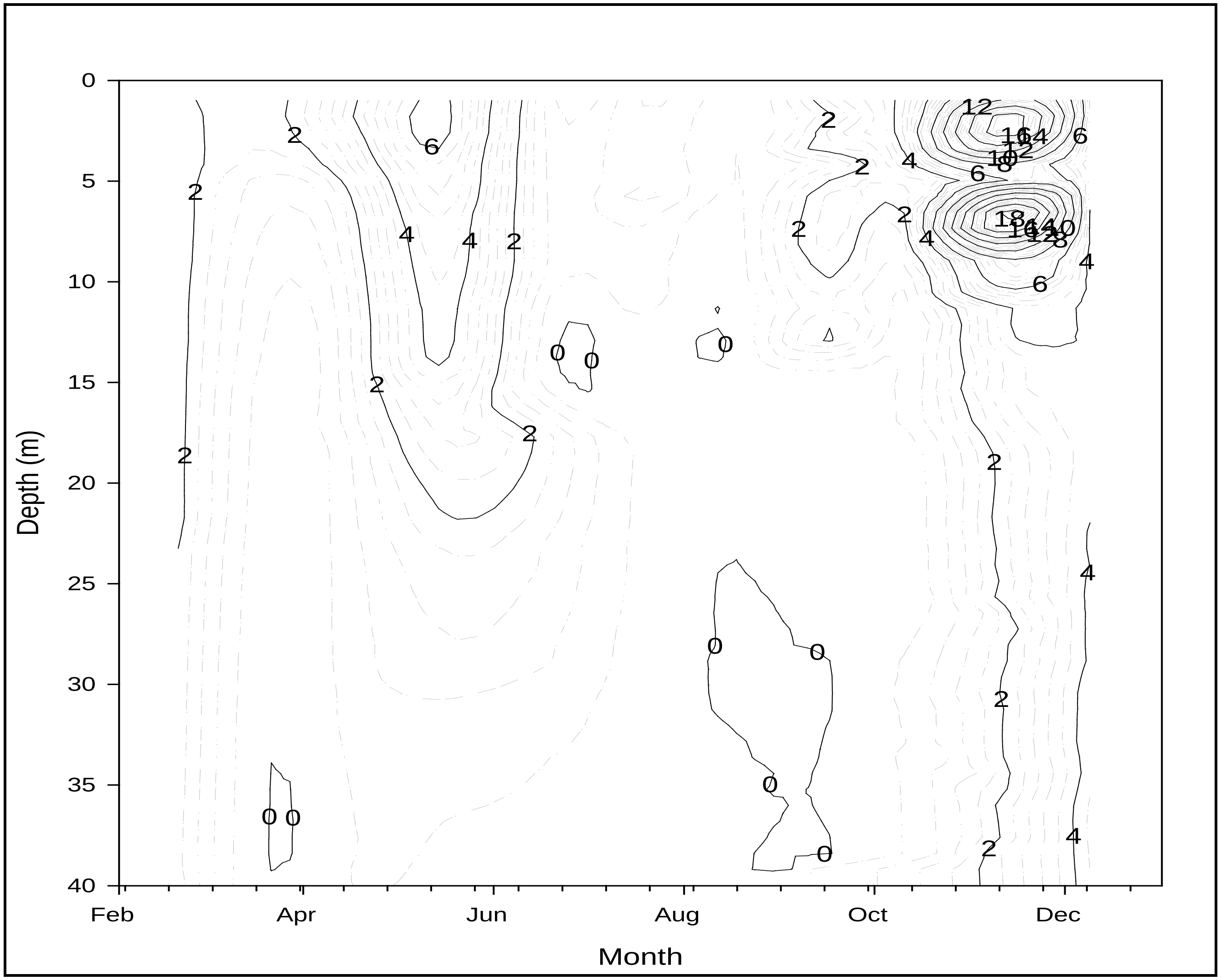

Figure 10. Dissolved oxygen profiles at Station 6, February – December 2014.

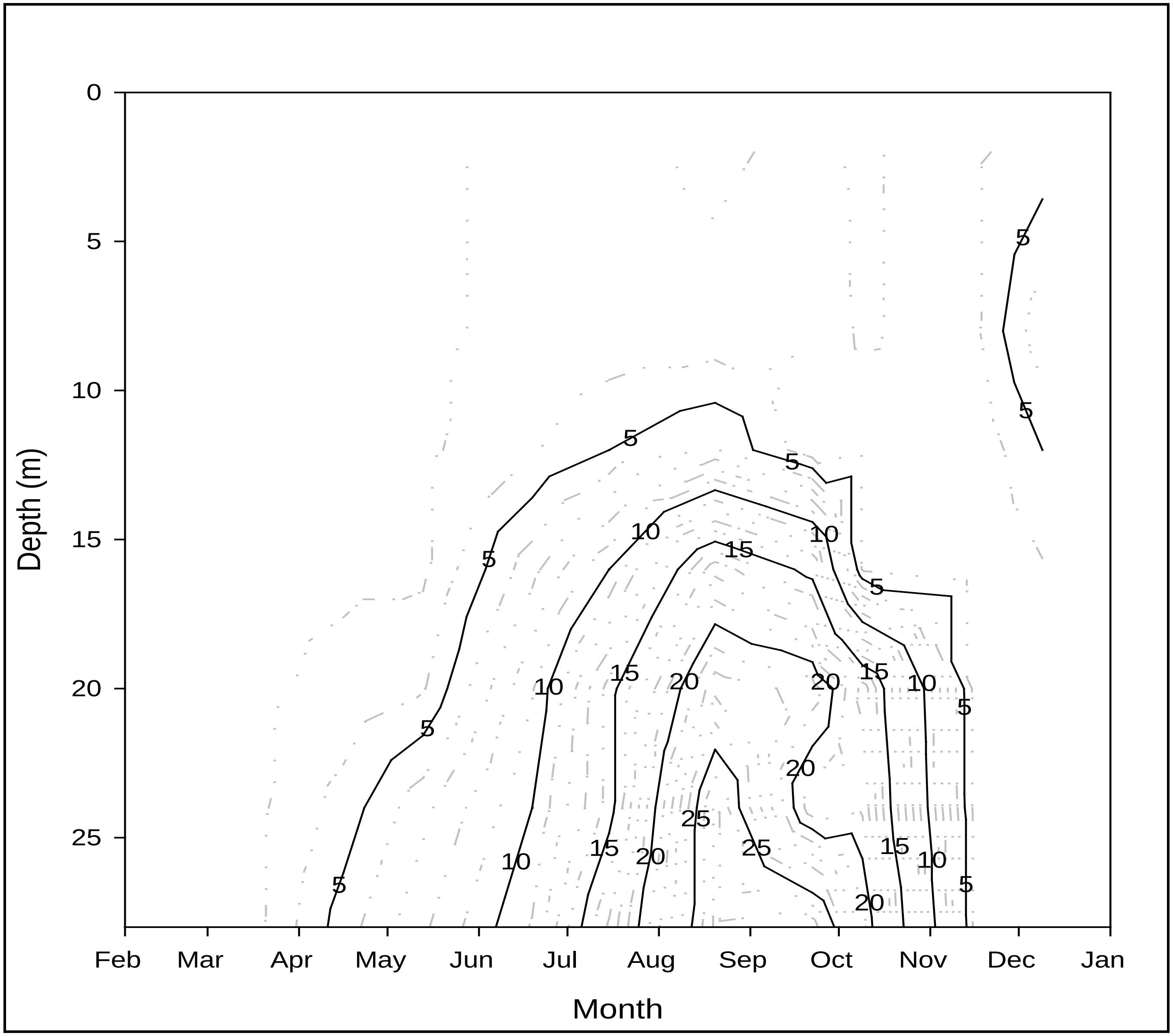

Figure 11. Ammonium profiles Station 6, February – December 2014.

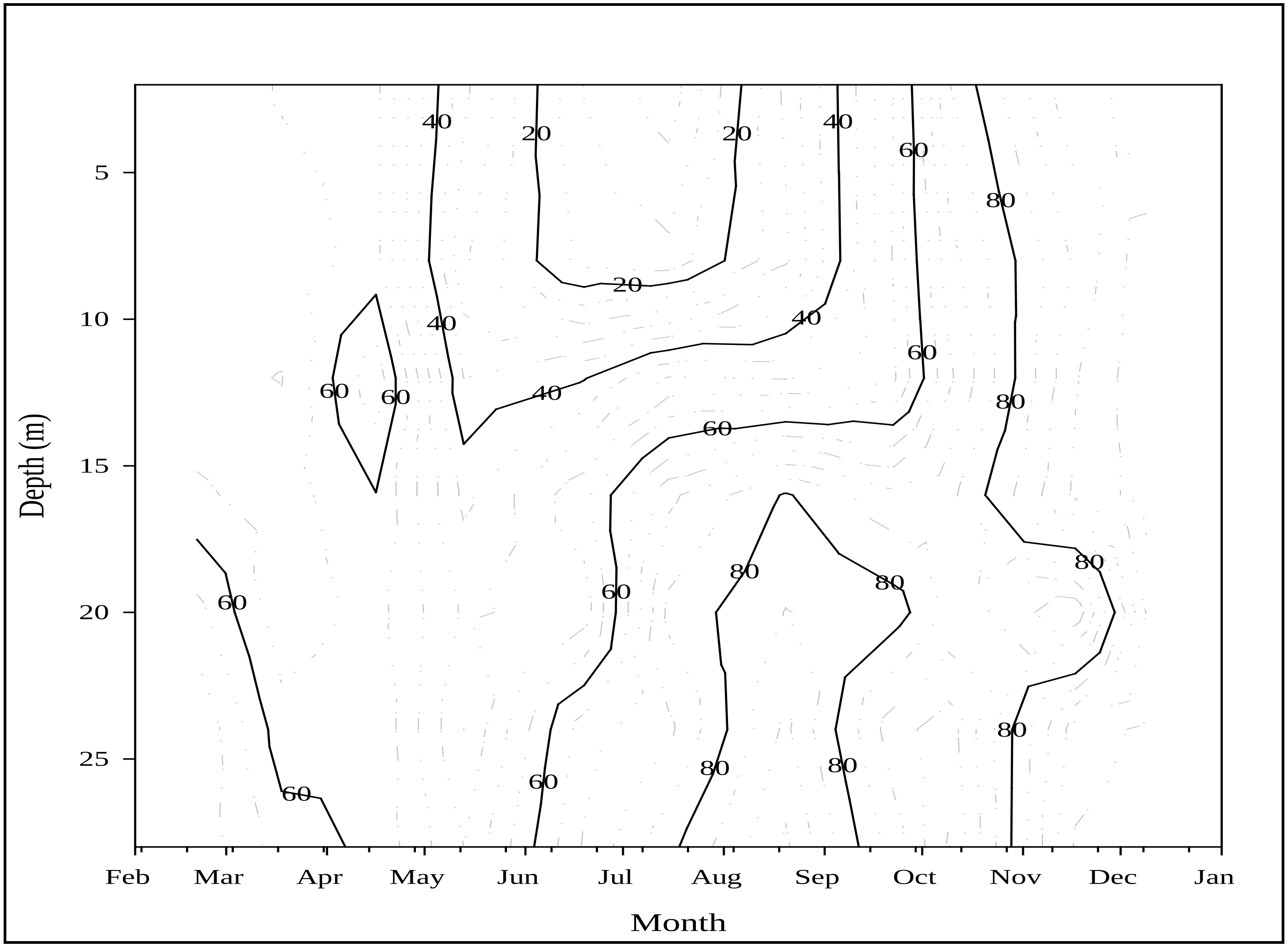

Figure 12. Chlorophyll *a* profiles at Station 6, February – December 2014.

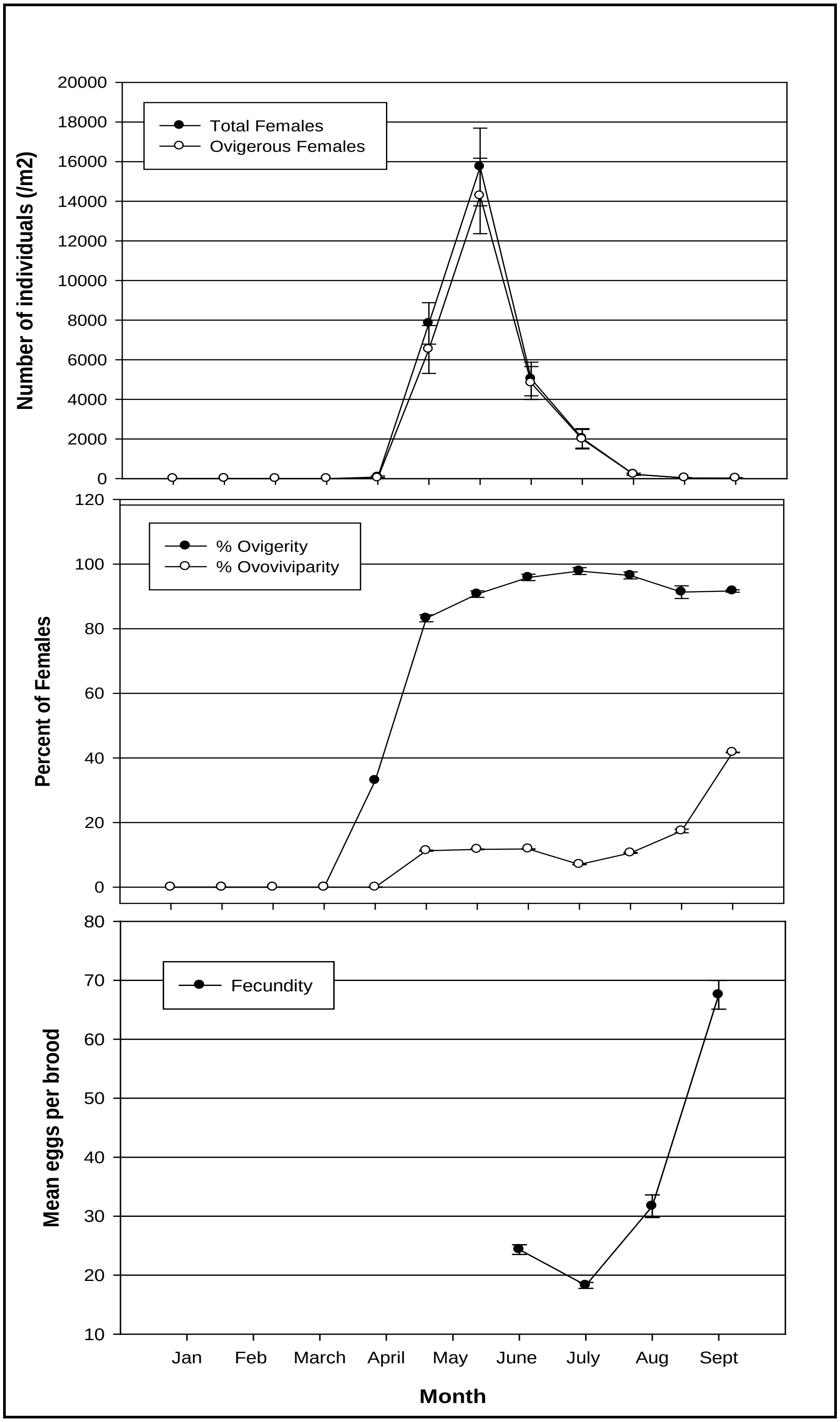

Figure 13. *Artemia* reproductive parameter and fecundity, 2014.

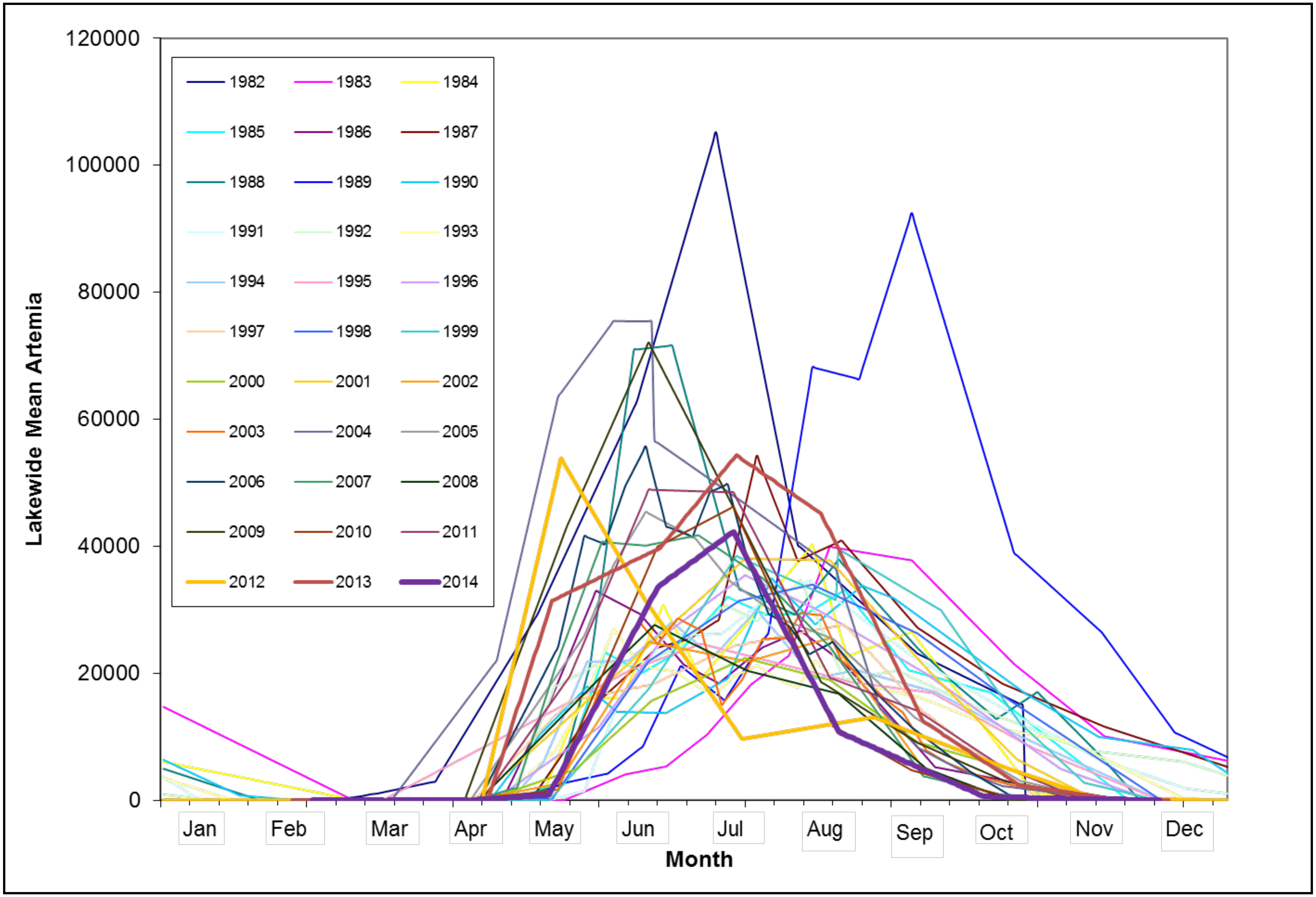

Figure 14. Mean lakewide *Artemia* abundance 1982-2014.

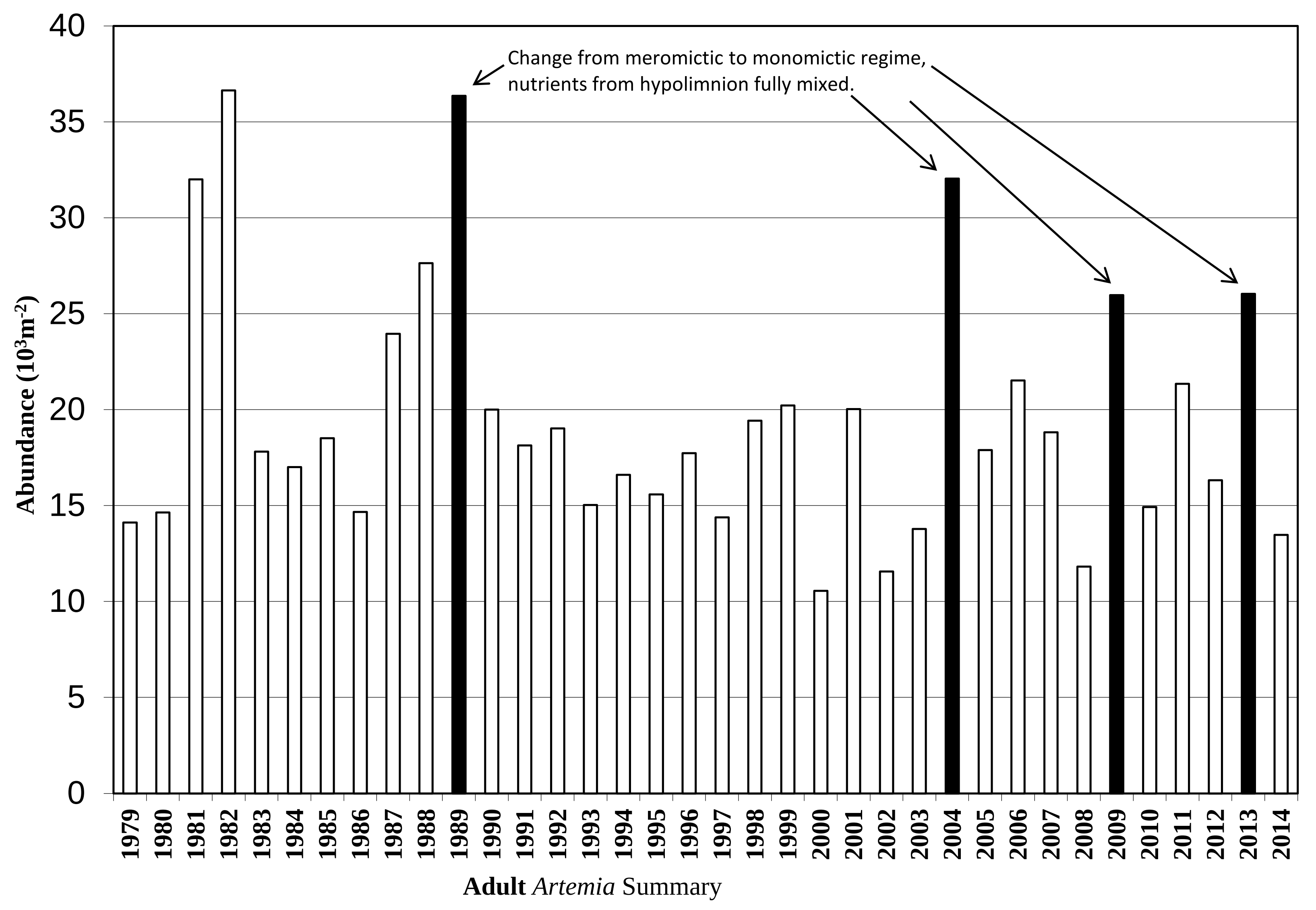

Figure 15. Mean adult *Artemia* abundance from 1979-2014 (May-November), indicating years subsequent to onset of monomixis.

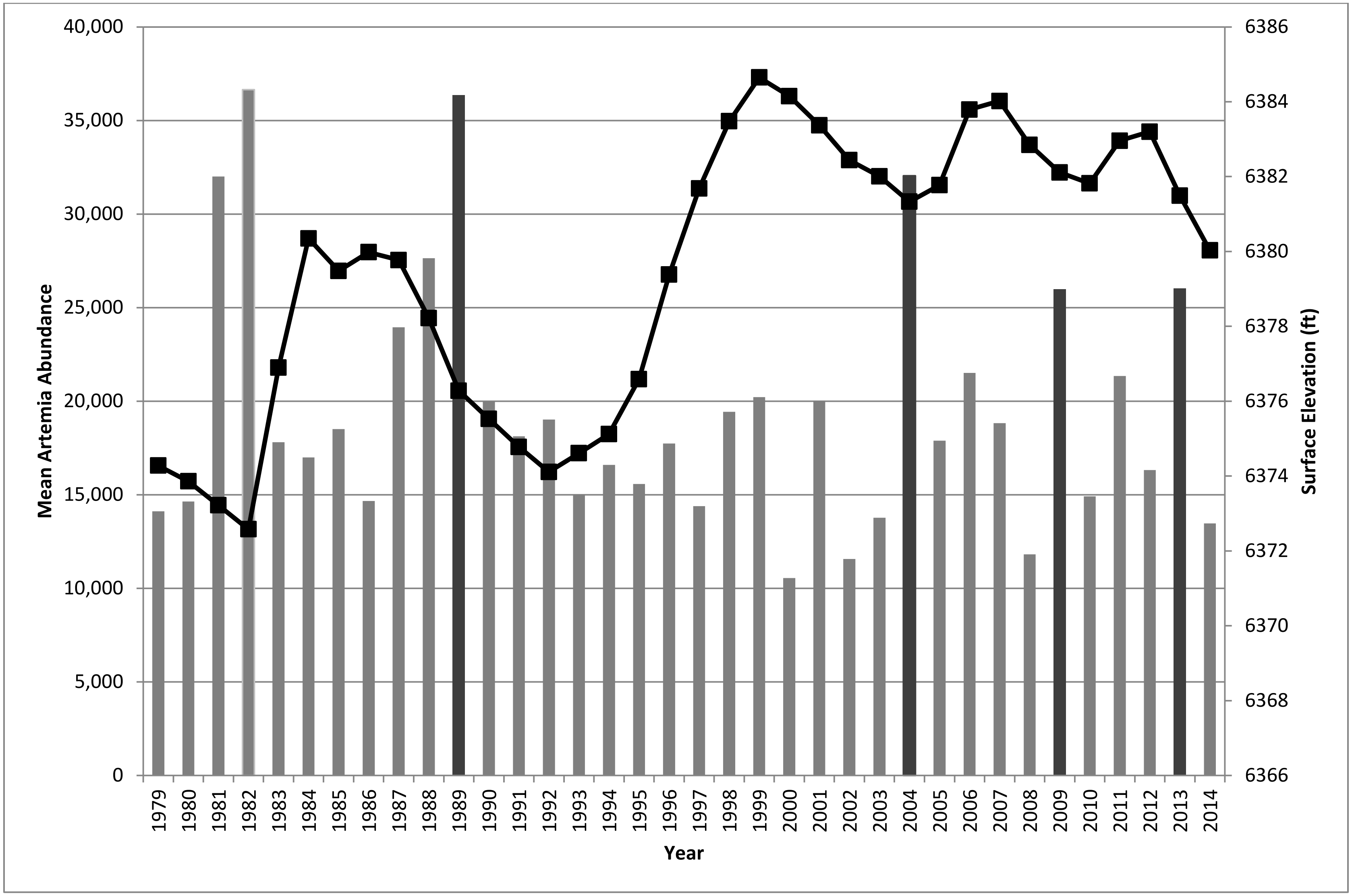

Figure 16. Mean surface elevation of Mono Lake from 1979-2014 denoted by black line. Gray bars indicate mean shrimp abundance per year (May-November). Dark gray bars indicate years subsequent to shift from meromictic to monomictic regime.

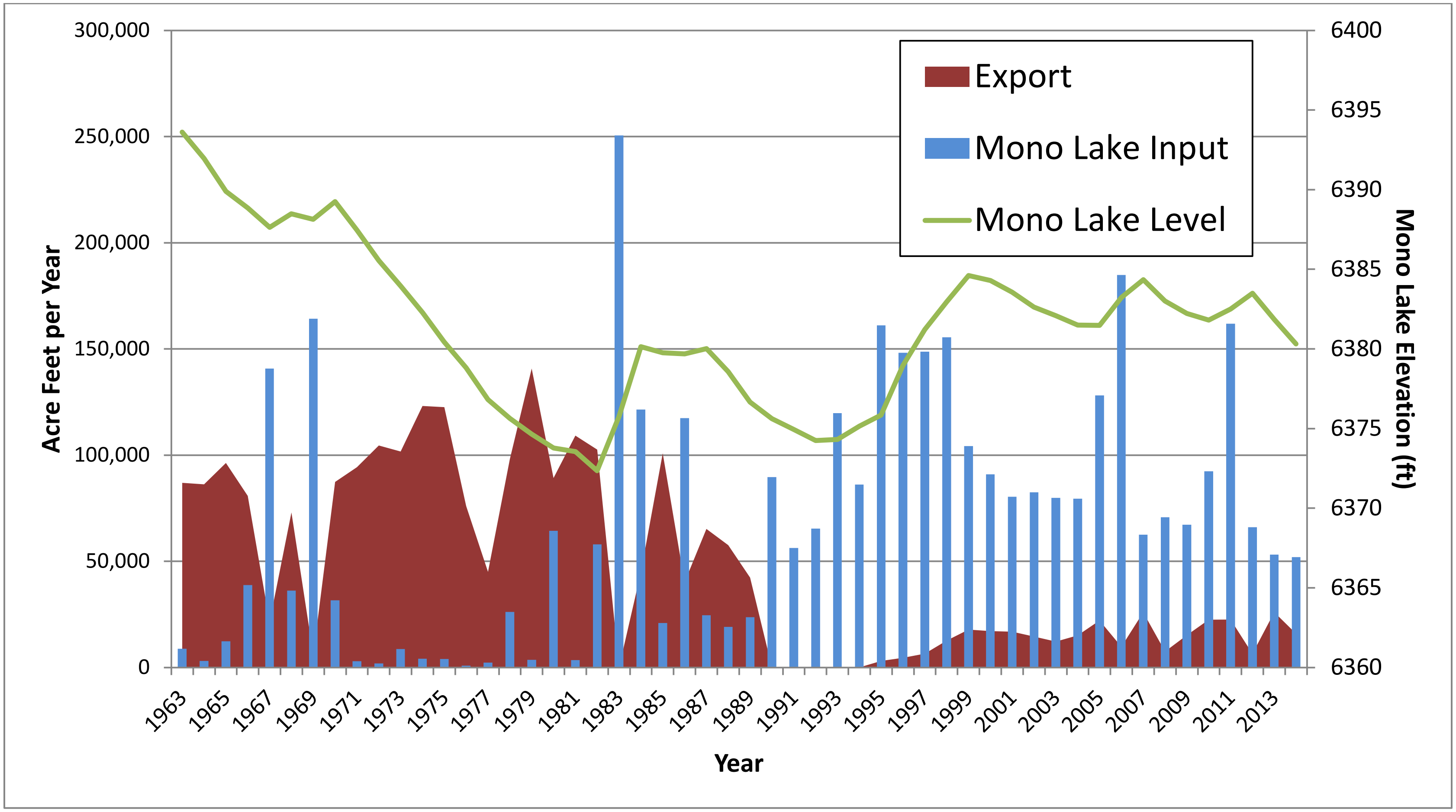

Figure 17. Annual export of water from Mono Lake tributaries, input to Mono Lake and surface elevation from 1963-2014 reported in acre feet per water year (April-March). Data from LADWP database.

APPENDIX 2

Ornithology

Mono Lake
Riparian & Fringing Wetlands
Landtype Inventory

MONO LAKE WATERFOWL POPULATION MONITORING

2014 Annual Report

PREPARED BY DEBBIE HOUSE
LOS ANGELES DEPARTMENT OF WATER AND POWER
WATERSHED RESOURCES SPECIALIST
PREPARED FOR STATE WATER RESOURCES CONTROL BOARD
BISHOP, CA 93514
March 2015

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EXECUTIVE SUMMARY

Waterfowl populations were monitored in 2014 at Mono Lake, Bridgeport Reservoir, and Crowley Reservoir, as a component of the 1996 Mono Basin Waterfowl Habitat Restoration Plan. At Mono Lake, three summer ground surveys were conducted, documenting species composition, habitat use and brood production. Six fall aerial surveys were conducted at Mono Lake, Bridgeport Reservoir, and Crowley Reservoir, providing an index of waterfowl numbers using each body of water during fall migration. The fall aerial surveys of Bridgeport and Crowley Reservoirs are being conducted in order to provide data to determine whether or not long-term trends observed at Mono Lake are mirrored at other Eastern Sierra water bodies or are specific to Mono Lake.

The elevation of Mono Lake has undergone annual variations in response to runoff conditions and precipitation regimes. The 2014 runoff year in the Mono Basin (April 1, 2014 - March 31, 2015) was a “dry” year type with 48% of average runoff predicted. Mono Lake was at its highest level in 2014 in April at 6380.7 feet, and dropped a total of 1.8 feet during the year to a low of 6378.9 feet by December.

A total of 773 waterfowl of eight species were recorded during summer surveys with Gadwall accounting for 53% of all detections. The four species that used the Mono Lake shoreline habitats for brooding in 2014 were Canada Goose, Gadwall, Green-winged Teal, and Mallard. The number of broods detected along shoreline habitats at Mono Lake in 2014 (31) was the lowest observed since ground-based surveys were initiated in 2002. The majority of waterfowl broods were found in the Mill Creek delta area. The primary lake-fringing habitats used in 2014 were ria and freshwater ponds. A total of eight broods were observed at the Restoration Ponds in 2014.

Fall aerial surveys of Mono Lake recorded a total of 21,898 individuals and fifteen waterfowl species. Northern Shoveler and Ruddy Duck were the dominant species during fall migration with Northern Shoveler accounting for 51% (11,305) of all detections and Ruddy Duck accounting for 28% (6,263) of all detections. The peak one-day count of 8,171 waterfowl occurred on the September 3 survey.

A total of 13,119 individuals and sixteen waterfowl species were recorded at Bridgeport Reservoir during fall aerial surveys. The most abundant species were Northern Shoveler and Canada Goose. The peak number of waterfowl detected at Bridgeport Reservoir was 2,583, and occurred on November 12.

A total of 82,006 individuals and 18 waterfowl species were recorded at Crowley Reservoir during the six fall surveys. The most abundant species were Ruddy Duck, Northern Shoveler, and Mallard. The peak number detected at Crowley Reservoir was 17,657 and occurred during the October 1 survey.

Use of Mono Lake by waterfowl during fall migration has not shown correlations with lake elevation or lake elevation change. There has been no trend in total waterfowl use of the lake in fall for the period 2002-2014. No correlation has been observed between the total waterfowl detected at Mono Lake and either Bridgeport or Crowley Reservoir.

Waterfowl Monitoring Compliance

This report fulfills the Mono Lake waterfowl population survey and study requirement set forth in compliance with the State Water Resources Control Board (SWRCB) Order No. 98-05. The waterfowl monitoring program consists of summer ground counts at Mono Lake, fall migration counts at Mono Lake, fall comparative counts at Bridgeport and Crowley Reservoirs, and photos of waterfowl habitats taken from the air. Three summer grounds counts and six fall aerial surveys were conducted at Mono Lake in 2014. Six comparative fall aerial counts were completed at Bridgeport and Crowley Reservoirs. Photos of shoreline habitats were taken from a helicopter on October 21, 2014.

2014 Mono Lake Waterfowl Population Monitoring
Los Angeles Department of Water and Power
Prepared by Debbie House
Watershed Resources Specialist
Bishop, CA

INTRODUCTION

In 1996, the Mono Basin Waterfowl Habitat Restoration Plan (Plan) was prepared by the Los Angeles Department of Water and Power (LADWP) for the State Water Resources Control Board (SWRCB) (LADWP 1996). This plan identified restoration objectives and potential projects in addition to land management efforts designed to mitigate for the loss of waterfowl habitat due to the lowered elevation of Mono Lake. The key components of the Plan are:

a) increasing the water surface elevation of Mono Lake to 6,392 feet,
b) rewatering Mill Creek,
c) rewatering specific distributaries in the Rush Creek bottomlands,
d) implementation of the DeChambeau Pond and County Pond Restoration Project,
e) development and implementation of a prescribed burn program, and
f) control of saltcedar in lake-fringing wetlands.

The item identified as being the restoration measure of highest importance and priority was to increase the water surface elevation of Mono Lake to 6,392 feet.

SWRCB Order WR 98-05 directed LADWP to implement the above restoration measures in the Plan and conduct monitoring to assess the success of waterfowl habitat restoration efforts. Components of the waterfowl habitat monitoring plan include the monitoring of lake levels, lake limnology and secondary producers, the mapping of riparian and lake-fringing wetland habitats, and waterfowl population surveys. The purpose of the waterfowl population survey component of the Plan is to provide information to track changes in population levels of waterfowl and assess waterfowl use of the various wetland habitats.

This report describes and discusses monitoring efforts related to evaluating waterfowl population responses to increases in Mono Lake water surface elevations. Survey data for the DeChambeau and County Restoration Ponds are also presented.

Summer ground surveys were conducted in order to determine the size of the breeding and/or summering population, species composition, spatial distribution and habitat use of waterfowl during the summer. Fall aerial surveys were conducted to provide an index of waterfowl numbers using Mono Lake during fall migration, as well as provide information on species composition and spatial distribution. Fall waterfowl surveys are also conducted at Bridgeport and Crowley Reservoirs in order to provide data to evaluate whether long-term trends observed at Mono Lake are mirrored at other Eastern Sierra water bodies or are specific to Mono Lake.

All summer surveys were conducted by the author. Fall surveys were conducted by the author with assistance from Mr. Chris Allen, LADWP Watershed Resources Specialist.

METHODS

Summer Ground Surveys

Three ground-count surveys were conducted at Mono Lake at three-week intervals beginning in early June. All surveys were conducted as area counts, and locations were surveyed either by walking along the shoreline, along creek corridors or by making observations from a stationary point. Ground surveys of all shoreline locations were completed over four to five-days.

Shoreline locations surveyed were those identified in the Plan as current or historic waterfowl concentration areas (Figure 1), namely: South Tufa (SOTU); South Shore Lagoons (SSLA); Sammann's Spring (SASP); Warm Springs (WASP); Wilson Creek (WICR); Mill Creek (MICR); DeChambeau Creek Delta (DECR); Rush Creek Delta (RUCR); and Lee Vining Creek bottomlands and delta (LVCR). Surveys were also conducted at the restoration ponds north of the lake: DeChambeau Ponds (DEPO) and County Ponds (COPO).

Shoreline areas including SOTU, SSLA, SASP, WASP, DECR, WICR, and MICR were surveyed by traversing the entire shoreline segment on foot, following the shoreline. In RUCR and LVCR, the creeks were surveyed from the County Road to the deltas. Surveys along lower Rush Creek were conducted by walking along the southern bluff above the creek, and traversing the delta along existing sandbars. This route offered a good view of the creek while limiting wildlife disturbance and flushing of waterfowl ahead of the observer. In Lee Vining Creek, surveys of the creek channel were conducted by walking along the north bank of the main channel, which offered the best view of the channel. At the mouth of the creek, the main channel splits in two and forms two delta areas separated by a tall earthen berm-like formation. In order to obtain good views of both delta areas, it was necessary to cross the main channel and walk on top of this berm. After viewing both delta areas from the berm, the delta areas were also traversed. In both areas, birds were observed and recorded within 100 meters on either side of the deltas.

At the Restoration Ponds, observations were taken from stationary points that allowed full viewing of each pond. A minimum of five minutes was spent at each observation point at the DeChambeau and County Ponds.

All summer ground surveys began within one hour of sunrise and were completed within approximately six hours. The order in which the various sites were visited was varied in order to minimize the effect of time-of-day on survey results. Total survey time was recorded for each area. The date and time of day for each survey during 2014, are provided in Appendix 1. The common names and scientific names for species referenced in the document can be found in Appendix 2.

Surveys along the shoreline and in Rush and Lee Vining Creeks were conducted by walking at an average rate of approximately 1.5 km/hr, depending on conditions, and recording waterfowl species as they were encountered. Because waterfowl are easily flushed, and females with broods are especially wary, the shoreline was frequently scanned well ahead of the observer in order to increase the probability of detecting broods. The following was recorded for each waterfowl observation: time of the observation; the habitat type being used; and an activity code indicating how the bird; or birds were using the habitat. The activity codes used were resting, foraging, flying over, nesting, brooding, sleeping, swimming, and “other”. Shorebirds were censused in the same manner; however, shorebird data will not be presented in this document.

When a waterfowl brood was detected, the size of the brood was recorded, a GPS reading was taken (UTM, NAD 27, Zone 11, CONUS), and the location of each brood was marked on an aerial photograph while in the field. Each brood was also assigned to an age class based on its plumage and body size (Gollop and Marshall 1954). Since the summer surveys were conducted at three-week intervals, any brood assigned to Class I using the Gollop and Marshall age classification scheme (which includes subclasses Ia, Ib, and Ic), would be a brood that had hatched since the previous visit. Assigning an age class to broods allowed for the determination of the minimum number of “unique broods” using the Mono Lake wetland and shoreline habitats.

The habitat categories used, generally follow the classification system found in the report entitled 1999 Mono Basin Vegetation and Habitat Mapping (LADWP 2000b). The habitat classification system defined in that report is being used for the mapping of lakeshore vegetation and the identification of changes in lake-fringing wetlands associated with changes in lake level. The specific habitat categories used in that mapping effort (and in this project) include: marsh, wet meadow, alkaline wet meadow, dry meadow/forb, riparian scrub, Great Basin scrub, riparian forest, freshwater stream, ria, freshwater pond, brackish ponds, hypersaline ponds, and unvegetated. Salinity measurements of ponds were taken using an Extech EC400 Conductivity/TDS/Salinity probe in order to aid in the proper classification of fresh versus brackish ponds when recording habitat use. Ponds with a salinity of less than 500 ppm were classified as fresh. Ponds with vegetation present and a salinity of greater than 500 ppm were classified as brackish. Ponds which lacked vegetation and freshwater inflow were classified as hypersaline. For reference, the definition of each of these habitat types is provided in Appendix 3. Representative photos of these habitats can be found in the report entitled *Mono Lake Waterfowl Population Monitoring 2002 Annual Report* (LADWP 2003).

Two additional habitat types: open-water near-shore (within 50 meters of shore), and open-water offshore (>50 meters offshore), were added to the existing classification system in order to more completely represent areas used by waterfowl. Although a “>50 meter” category was used at the time of data collection, these observations will not be included in the final calculations unless the presence of waterfowl in the open-water offshore zone was determined to be due to observer influence (e.g., the observer sees that a female duck is leading her brood offshore and is continuing to swim away from shore).

Fall Aerial Surveys

Overview of Methodology

Aerial surveys were conducted in the fall at Mono Lake, Bridgeport Reservoir, and Crowley Reservoir using a small high-winged airplane. A total of six surveys were conducted at two-week intervals, with the first survey beginning during the first week of September, and the final fall survey occurring in the middle of November. A summary of the fall survey schedule has been provided as Appendix 4.

Each aerial survey began at Mono Lake at approximately 0900 hours. Mono Lake was surveyed in approximately one and one-half hours. Bridgeport Reservoir was surveyed next, and Crowley Reservoir was surveyed last. In all cases, surveys of all three waterbodies were completed in a single flight by 1200 hours on the day of the survey.

At Mono Lake, waterfowl and shorebirds were censused, with the primary emphasis on the censusing of waterfowl. The greater concentration and diversity of waterfowl at Bridgeport and Crowley Reservoirs prevents censusing of shorebirds at these locations. This report will only present waterfowl data. Observations were verbally recorded onto a handheld digital audio recorder and later transcribed by the observer.

A second observer was present on all six flights. At Mono Lake, the second observer sat on the same side of the plane as the primary observer during the perimeter flight and censused shorebirds. During the cross-lake transect counts, observers sat on the opposite sides of the plane and counted Ruddy Ducks and other waterfowl, and phalaropes occurring on the open water. At Bridgeport and Crowley, the second observer sat on the same side of the plane as the primary observer during the entire survey, and assisted in waterfowl counts.

Mono Lake Aerial Surveys

Aerial surveys of Mono Lake consisted of a perimeter flight of the shoreline and a set of fixed cross-lake transects. The shoreline was divided into 15 lakeshore segments (Figure 2) in order to document the spatial use patterns of fall migrant waterfowl. Coordinates forming the beginning of each segment were derived from the 2002 aerial photo of Mono Lake (2002 aerial image taken by I. K. Curtis, and processed by Air Photo, USA) and can be found in Appendix 5, along with the four-letter code for each lakeshore segment. The segment boundaries are the same as those used by Jehl (2002), except for minor adjustments made in order to provide the observer with obvious landmarks that are easily seen from the air.

The cross-lake transects covered open water areas of Mono Lake. The eight transects are spaced at one-minute (1/60 of a degree, approximately one nautical mile) intervals and correspond to those used by Boyd and Jehl (1998) for the monitoring of Eared Grebes during fall migration. The latitudinal alignment of each transect is provided in Appendix 6.

Each of the eight transects is further divided into two to four sub-segments of approximately equal length (Figure 2). The total length of each cross-lake transect was first determined from the 2002 aerial photo. These lengths were then sub-divided into the appropriate number of subsections to a total of twenty-five sub-segments, each approximately 2-km in length. This approach creates a grid-like sampling system that allows for the evaluation of the spatial distribution of species occurring offshore. The beginning and ending points for each subsection were determined using landscape features, or, when over open water, by using a stopwatch, since the survey aircraft's airspeed was carefully controlled and the approximate length of each subsection was known.

LADWP contracted with Black Mountain Air Service to conduct fixed-winged aerial counts. Black Mountain Air Service has obtained a low-altitude flight waiver from the Federal Aviation Administration in order to conduct these flights. Aerial surveys were conducted in a Cessna 180 at a speed of approximately 130 kilometers per hour, and at a height of approximately 60 meters above ground. Perimeter surveys were conducted over water while maintaining a distance of approximately 250 meters from the shoreline. When conducting aerial surveys, the perimeter flight was conducted first, and in a counterclockwise direction, starting in the Ranch Cove area. Cross-lake transects were flown immediately afterward, starting with the southernmost transect and working northwards.

In order to reduce the possibility of double-counting, only birds seen from or originating from the observer's side of the aircraft were recorded. Even though the flight path of the aircraft along the latitudinal transects effectively alternated the observer's hemisphere of observation in a North-South fashion due to the aircraft's heading on successive transects, the one-nautical-mile spacing between the transects worked in conjunction with the limited detection distance of the waterfowl (<< 0.5 nautical mile) to effectively prevent double-counting of birds on two adjacent transects.

Bridgeport Reservoir Aerial Surveys

The shoreline of Bridgeport was divided into three segments (Figure 3). Appendix 5 contains the four-letter code for each lakeshore segment and the coordinates of the beginning of each section. Survey flights started at the dam at the north end of the reservoir and proceeded counterclockwise. The distance from shore, flight speed, and height above ground were the same as employed at Mono Lake. Adjustments were made as necessary depending on lighting, lake level and waterfowl distribution. The reservoir was circumnavigated twice during each survey to allow for a second count of often large concentrations of mixed species flocks.

Crowley Reservoir Aerial Surveys

The shoreline of Crowley Reservoir was divided into seven segments (Figure 4). Coordinates forming the beginning of each segment were generated from the 2000 aerial photo of Crowley Reservoir (2000 aerial image taken by I. K. Curtis, and processed by Air Photo, USA) and can be found in Appendix 5, as well as the four-letter code used for each segment. Each survey began at the mouth of the Owens River (UPOW) and proceeded over water in a counterclockwise direction along the shoreline. The distance from shore, flight speed, and height above the water were the same as at Mono Lake during most of each flight. Temporary diversions of distance from shore or height above ground were made by the pilot as necessary to avoid direct or low flight over float-tubers or boats. Adjustments were also made as necessary depending on lighting, lake level and waterfowl distribution. The reservoir was circumnavigated twice during each survey to allow for a second count of often large concentrations of mixed species flocks.

Ground Verification Counts

Ground verification counts were conducted whenever flight conditions (e.g., lighting, background water color, etc.) did not allow the positive identification of a significant percentage of the waterfowl encountered, or to confirm the species or number of individuals present. During a ground validation count, the total number of waterfowl present in an area was recorded first, followed by a count of the number of individuals of each species present.

Photo Documentation

As required by the SWRCB Order 98-05, photo documentation of lake-fringing waterfowl habitats was completed in 2014. Photos were taken from a helicopter at all bodies of water on October 21, 2014. Photos depicting the condition and available habitats for each shoreline segment are described under Data Summary below.

Data Summary and Analysis

2014 Summer Ground Count Data

Total detections of each species were summed by lakeshore segment for each survey. Total detections were also summed over the entire summer survey period, and the percent of total detections per lakeshore segment was calculated. Total numbers of broods per species, survey and lakeshore segment were also summed. Waterfowl habitat observations were summed for all species except flyovers and data only for those species for which at least 30 observations were obtained will be presented.

2014 Fall Aerial Count Data

For each survey and water body, the total number of waterfowl of each species was summed by lakeshore segment and survey. The spatial distribution of waterfowl at each body of water was determined by calculating the proportion of all fall detections that occurred in each lakeshore segment or offshore (for Mono Lake). This calculation was done excluding Ruddy Duck numbers. Ruddy Ducks occur on the open water and therefore their occurrence in particular region is not expected to be tied directly to shoreline features affected by lake levels.

Trend Analysis

Although many factors likely affect waterfowl use of Mono Lake, trends in waterfowl use were analyzed relative to lake elevation, which is the primary waterfowl habitat restoration tool identified in the Plan. Pearson Product Moment Correlation (Sigma Stat 3.5) was used to evaluate the relationship between lake elevation and summer waterfowl abundance, diversity, and total number of broods detected. Fall waterfowl populations at Mono Lake were also evaluated for correlations between total waterfowl detections, numbers of Northern Shoveler and Ruddy Duck and September lake elevation, and lake elevation change from previous year. To compare use of each water body by waterfowl, using the waterfowl numbers as an index, the total waterfowl detected each fall was summed for each year 2002-2014. Median values of total waterfowl and the presence of outliers were evaluated using box plot diagrams. Count data were evaluated for correlations between total waterfowl use among each of the three water bodies. In addition, the relative use of the three water bodies by Northern Shoveler and Ruddy Duck was also evaluated using two-way Analysis of Variance.

RESULTS

Description of Shoreline Conditions in 2014

Mono Lake

The 2014 runoff year (April 1, 2014 - March 31, 2015) in the Mono Basin was a “Dry” year type with a predicted runoff of 48% of the 1941-1990 average runoff (see Order WR 98-05). During the 2014 runoff year, Mono Lake was at its highest in elevation in April 2014 at 6380.7 feet. The lake level steadily declined throughout the year lowering a total of 1.8 feet to a low of 6378.9 feet in December. In early summer (June) the lake level was 6380.4 feet, or 1.5 feet lower than it had been during the same time in 2013. The lake level continued to decline through the summer and at the start of fall surveys in September, the elevation was 6379.6 feet, which was 1.4 feet lower than September 2013. The decrease in lake elevation as compared to 2013 resulted in qualitative differences in lake-fringing habitats for waterfowl during the 2014 monitoring period, some of which are discussed below.

South Shoreline Areas (South Tufa, South Shore Lagoons, and Sammann’s Spring)

The South Tufa area west of Navy Beach has typically exhibited fairly wet conditions, supporting extensive mudflats or flooded meadow habitats, depending on the lake elevation. Throughout the summer 2014, however, the shoreline in this reach was noticeably dry, a condition that has not been encountered since ground waterfowl surveys were initiated in 2002. East of Navy Beach, presumed shoreline subsidence resulted in the development of an ephemeral brackish pond present in early June. As the lake level continued to decline, the shoreline showed a gradual drying through the remainder of the year. East of Navy Beach, dry conditions and a sandy shoreline lacking ponds or mudflats continued into fall (Figure 5).

As a result of declining lake levels that have occurred since 2012, the only ponds available for waterfowl in the South Shore Lagoons area in 2014 were in the Goose Springs area and Sand Flat Spring. Semi-permanent ponds in the area were dry including the brackish pond at the extreme west end of the South Shore Lagoons area, (Figure 6) and the semi-permanent freshwater pond approximately 1.2 km farther east from this first pond. At Sand Flat Spring (Figure 8), the water continued to seep from the spring to the lake through the loose sand, creating some mudflats and foraging opportunities for shorebirds and waterfowl. The extent of emergent vegetation in the lower pond at Sand Flat Spring expanded, resulting in an almost complete loss of open water in this pond and a decrease in habitat quality for waterfowl. The main area of waterfowl use in 2014 along the South Shore Lagoons area was the Goose

Springs outflow area (Figure 9). The shoreline freshwater pond downgradient of Goose Springs persisted, however there was no longer outflow from the pond to the lake.

In the Sammann's Spring area, the decline in lake elevation resulted in additional expansion of unvegetated shoreline. West of Sammann's Spring faultline, emergent vegetation encroached on shallow fresh water ponds upgradient of a large littoral bar, decreasing the available open water habitat in this area. In the Sammann's Spring area, spring flow normally reaches the lake at numerous points through breaks in the littoral bars, creating very wet shoreline conditions and extensive mudflats. By the end of the summer, spring flow in several channels west of the faultline had dried by the end of the summer and flow was no longer reaching the lake. Despite this change, the Samman's Spring shoreline area west of the fautline still appeared fairly wet through fall (Figure 10) due to numerous springs in this reach. Immediately east of the faultline, brackish shoreline ponds persisted (Figure 11) and receive moderate use by waterfowl in summer and fall.

Warm Springs and Northeast Shore

In contrast to other areas, flooding was more extensive in the Warm Springs shoreline area than in 2013 (Figure 12), and flow was observed from a spring that has been dormant for at least since 2002. The "north pond" at Warm Springs, a semi-permanent brackish pond supported by the outflow of Pebble and Twin Warm Springs, continued to be the main area of waterfowl use. Ponds to the south which are supported by outflow from Warm Springs Marsh Channel, Warm B, and Bug Warm springs, were also flooded in 2014 but received minimal use by waterbirds. Apparent subsidence of the shoreline in the Warm Springs area resulted in the development of a series of ephemeral brackish ponds downgradient of springs and existing semi-permanent ponds. Although there was no direct connection to the lake from spring channels, these brackish ponds were receiving water input by way of seepage through the loose sandy soil in this region. The Northeast Shore was dry, there were no ephemeral ponds present, and this area supported only barren playa (Figure 13).

Bridgeport Creek, DeChambeau Embayment and Black Point

This area of the shoreline typically consists of several small ponds with alkali meadow adjacent. The main springs in this reach are found in the Bridgeport Creek shoreline segment, with Perseverance and Chuck Spring generally supporting the best waterfowl habitat in the area. The Bridgeport Creek shoreline area was fairly dry and spring flow did not appear to reach the lake in this region. In the DeChambeau Embayment area, however, spring flow continued to reach the lake with the main area of waterfowl use in the fall at Perseverance Spring in the DeChambeau Embayment area (Figure 15). The Black Point shoreline area was dry and appeared to lack notable waterfowl resources (Figure 16).

Northwest Shore (Wilson, Mill Creek and DeChambeau Creeks)

In the Wilson Creek area, the decrease in lake elevation resulted in an increase in the amount of exposed sandy shoreline and mudflats (Figure 17). The small beaver dam near the outflow of Black Point Seep was still present but only limited use of the beaver pond by waterfowl was observed in 2014. In the Mill Creek delta, shoreline retraction seemed less apparent than in other areas. There continues to be extensive beaver activity in the delta, and openings in the willow canopy created by this beaver activity are becoming more apparent on aerial images (Figure 18). Head cuts were noted at the outflow channels of Mill Creek. In the DeChambeau Creek area the decrease in lake elevation resulted in further increases in the amount of exposed shoreline and some drying of the shoreline (Figure 19).

West Shoreline (West Shore, Lee Vining Creek, Ranch Cove and Rush Creek)

The West Shore area (Figure 20) supports primarily meadow and riparian scrub habitats, but lacks ponds. No significant changes were noted in 2014, except an increase in exposed shoreline as was noted elsewhere. Due to the dry runoff year conditions, there was no stream restoration flow in Lee Vining Creek. Stream flows were maintained at base flow and water remained confined to the mainstem. The peak flow reached in Lee Vining in 2014 was 40.9 cfs on May 25. The continued decline in lake elevation resulted in increased exposure of mudflats and sandbars in the Lee Vining delta (Figure 21). The Ranch Cove area has limited fresh water input, and does not support ponds due to the gradient (Figure 22). The area continued to be dominated by sandy beach and upland vegetation. The decrease in lake elevation resulted in further increases in the exposure of sandbars and deltaic deposits in Rush Creek delta (Figure 23). There was no stream restoration flow release in Rush Creek due to the dry year conditions. The peak flow recorded in lower Rush Creek in 2014 was 58 cfs, on June 6.

Restoration Ponds

Both County Ponds were flooded in 2014. There was little open water visible at County Pond West due to the encroachment of emergent vegetation. DeChambeau Ponds 1 and 5 were dry in 2014 while ponds 2-4 were flooded.

Bridgeport Reservoir

Bridgeport Reservoir was at a very low level throughout fall. In September, Bridgeport Reservoir held 1,880 acre-feet (Department of Water Resources, California Data Exchange Center, (http://cdec.water.ca.gov/cgi-progs/queryMonthly?s=BDP&d=today), almost 33% fewer acre-feet than at the same time in 2013. As a point of reference, the storage capacity of Bridgeport Reservoir is 42,600 acre-feet. Figure 24 shows an overview of the reservoir as viewed from the south end looking north toward the dam. The south end of the reservoir, which includes the area referred to as “West Bay”, and part of the “East Shore” area, receives fresh water inflows from Buckeye and Robinson Creeks and the East Walker River, creating extensive mudflat areas adjacent to these creek inflow areas, especially when the reservoir is at a higher level. The low level of the reservoir in fall 2014 notably affected the West Bay area in particular as the extent of mudflats appeared markedly contracted. The northern arm of the reservoir includes primarily sandy beaches bordered by upland vegetation.

Crowley Reservoir

In early September, Crowley Reservoir held 77,147 acre-feet (Department of Water Resources, California Data Exchange Center, http://cdec.water.ca.gov/cgi-progs/queryMonthly?s=crw&d=today) essentially the same as in September 2013. As a point of reference, the storage capacity of Crowley Reservoir is 183,465 acre-feet. Figures 25-31 depict habitat conditions of each shoreline segment at Crowley Reservoir. Due to the low reservoir levels, exposed shore was apparent in all areas. The Upper Owens River delta area (Figure 25) includes large areas of exposed mudflats and reservoir bottom adjacent to the mouth of the Upper Owens River. Most of the length of Sandy Point area (Figure 26) is adjacent to elevated areas and upland vegetation. Small areas of meadow habitat occur in this area also. North Landing is largely bordered by dry meadows with no fresh water input (Figure 27) except near the western border. The McGee Bay area (Figure 28) supports vast mudflat areas immediately adjacent to wet meadow habitats, and receives inflow from McGee Creek. Hilton Bay (Figure 29) is surrounded by meadow habitats, and receives some fresh water input from Hilton Creek. The Chalk Cliffs area (Figure 30) lacks fresh water inflow areas and wetland habitats, and is dominated by sandy beaches adjacent to steep, sagebrush-covered slopes. Layton Springs provide some fresh water input at the southern border of this lakeshore segment. The remainder of the area is bordered by upland vegetation and a large area of sandy beach (Figure 31).

2014 Summer Ground Counts

Waterfowl abundance, distribution and brood counts

A total of 773 waterfowl of eight species were recorded during summer surveys (Table 1). Canada Goose, Gadwall, Mallard and Green-winged Teal were observed all three surveys. The most abundant species was Gadwall accounting for 53% of all detections (407/773). The next most abundant species were Canada Goose (22%) and Green-winged Teal (13%). The total number of waterfowl using the shoreline (exclusive of dependent young) detected during summer surveys was highest (340) during Survey 1 in early June count and lowest (106) on the late July survey (Survey 3) (Table 1).

The majority of waterfowl were found either in the South Shore Lagoons area, or along the northwest shore in the DeChambeau Creek, Mill Creek and Wilson Creek areas (Table 2). The fewest number of waterfowl were found at Lee Vining Creek (12; 1.6%) and South Tufa (26; 3.4% of detections). The most abundant and ubiquitous species was Gadwall which was found in all locations surveyed and was most numerous at Wilson Creek. Canada Goose, the second most abundant species, was most abundant at DeChambeau Creek. Green-winged Teal were most numerous at South Shore Lagoons and Mill Creek.

Waterfowl species observed with broods in the lake-fringing wetlands and creeks at Mono Lake in 2014 were Canada Goose, Gadwall, Green-winged Teal, and Mallard (Table 3). A total of 31 broods were found with Gadwall comprising the majority of broods found (22/31; 71%). Most waterfowl broods were found at Mill Creek, and no broods were found in Lee Vining Creek or at Warm Springs. Figure 32 shows the locations of all of the broods detected in 2013.

Habitat Use

Overall, the primary lake-fringing habitats used by waterfowl in 2014 were ria and freshwater ponds. Canada Geese were observed using primarily open water, and ria (Figure 33). Canada Geese was the only species that used meadow habitats to any extent, but were not observed in brackish or freshwater ponds. Gadwall were found primarily in ria areas, but also freshwater and brackish ponds, and unvegetated areas. Green-winged Teal were observed using primarily fresh water ponds and were not observed in brackish ponds or open water areas. Mallard primarily used freshwater streams and ponds, and brackish ponds to a lesser extent, but were not observed on the open water.

2014 Fall Aerial Surveys

Fall Aerial Survey Weather Conditions

Conditions were mild and dry through the entire fall survey period. Bridgeport and Crowley Reservoirs remained ice-free through mid-November.

Mono Lake

A total of fifteen waterfowl species and 21,898 individuals were recorded at Mono Lake during fall aerial surveys (Table 4). The peak number of waterfowl detected at Mono Lake on any single count was 8,171 and occurred on the September 3 survey (Table 4, Figure 34). While waterfowl abundance was highest in September, waterfowl species richness was lowest. Waterfowl species richness was highest in November after the arrival of late fall migrant species such as and diving ducks. Northern Shoveler (*Anas clypeata*) and Ruddy Duck (*Oxyura jamaicensis*) were the dominant species during fall migration with Northern Shoveler accounting for 51.6% (11,305), and Ruddy Duck accounting for 28.6% (6,263) of all detections. The peak number of Northern Shoveler (7,157) occurred on September 3, and the peak number of Ruddy Ducks (2,255) occurred on October 15.

The distribution of waterfowl at Mono Lake varied throughout the survey period (Table 5). Overall, approximately 62% of all waterfowl were seen in shoreline habitats, and 38% were found offshore. During September when dabbling duck species such as Northern Shoveler were most abundant, waterfowl were distributed primarily in shoreline habitats, where approximately 90% were found. By October, few Northern Shoveler remained at Mono Lake, and the waterfowl community was composed primarily of Ruddy Ducks. Most Ruddy Ducks are found away from the immediate shoreline, and thus during the month of October when Ruddy Ducks were the dominant species, the majority of waterfowl were recorded in offshore areas. Over 96% of all waterfowl recorded in offshore areas were Ruddy Ducks. The mid-November survey recorded an unusually high number of dabbling ducks, which were again found in shoreline habitats. The main shoreline areas of waterfowl use during fall 2014 were the northwest shore areas of Wilson Creek, and Mill Creek; DeChambeau Embayment; and the south shoreline areas of Sammann's Spring and South Shore Lagoons. The Wilson and Mill Creek delta areas accounted for a total of 25.6% of all fall waterfowl observed. A total of 10.9% of all waterfowl were recorded at the outflow of Perseverance Spring in the DeChambeau Embayment area. The September 16 flight was anomalous in that few waterfowl were in the Wilson and Mill Creek area, while a large flock of Northern Shoveler (1,545, or 40% of all waterfowl) were at Perseverance Spring. It was also noted that a paddleboarder was in the Wilson and Mill Creek delta area at the time of the survey. Along the south shore, waterfowl were seen concentrating primarily from the Sammann's Spring faultline west to the Goose Springs area of South Shore Lagoons where 14.6% of all waterfowl were observed. There were no waterfowl observed at Northeast Shore and there were only a few waterfowl seen in other areas namely Black Point, Bridgeport Creek, and South Tufa.

Bridgeport Reservoir

A total of 16 waterfowl species and 13,119 individuals were recorded at Bridgeport Reservoir during the 2014 fall aerial surveys (Table 6). The total individuals recorded at Bridgeport was the lowest of all survey years. The peak number of waterfowl detected on any single count at Bridgeport Reservoir was 2,583 individuals, which occurred on November 12 (Table 6, Figure 34). Waterfowl species richness was also greatest on this mid-November survey. Waterfowl numbers at Bridgeport were fairly consistent throughout fall. Northern Shoveler and Canada Goose were the most abundant species. High numbers of Canada Geese were present at Bridgeport Reservoir the entire survey period, with a peak number of 940 recorded on the mid-November survey. The most abundant species in terms of total detections, were Northern Shoveler (33.9%), Ruddy Duck (15.9%) and Gadwall (12.2%). The peak number of Northern Shoveler at Bridgeport was on September 4, and peak Ruddy Duck numbers were recorded on November 12.

The West Bay was the main area of waterfowl use at Bridgeport Reservoir, accounting for over 89% of all detections (Table 7). Most waterfowl are generally found resting on the mudflats or on the water off shore along the southwestern part of the reservoir from Robinson and Buckeye Creek north to the ditch. Secondarily, waterfowl were found in the outflow area of the East Walker River.

Crowley Reservoir

A total of 18 waterfowl species and 82,006 individuals were detected at Crowley Reservoir during the 2014 fall aerial surveys (Table 8). The peak number of waterfowl detected on any single count at Crowley Reservoir was 17,657 individuals and occurred on October 1 (Table 8, Figure 34). Waterfowl numbers remained high through then end of the survey period The most abundant species, in terms of total detections, were Ruddy Duck (24.4%), Northern Shoveler (20.8%), and Mallard (18.1%). Northern Shoveler numbers were highest through the end of September to early October, with the peak number recorded on September 16. The number of Ruddy Ducks increased in early October, peaked in late-October, and remained high through mid-November.

McGee Bay continued to be the main area of waterfowl use at Crowley Reservoir throughout fall, while the secondary area of use was the Upper Owens River delta (Table 9). Few waterfowl were observed in the Chalk Cliffs area in early fall, but use of this area increased in November, as is typical after waterfowl hunting season commences.

Mono Lake Restoration Ponds

A total of seven species and 41 waterfowl were detected at the Restoration Ponds during summer surveys (Table 10). Most of the waterfowl use was in County Pond East. The most abundant species at the Restoration Ponds were Ruddy Duck and Gadwall. A total of eight broods were seen at the Restoration Ponds including four Gadwall, one Cinnamon Teal, and three Ruddy Duck broods (Table 11).

A total of 85 waterfowl were detected at the County Ponds (Table 12), with the majority of birds observed in County Pond east. Twenty-eight waterfowl were observed at the DeChambeau Pond complexes, with most seen in pond 4.

Trend Analysis

Summer Waterfowl

The total number of waterfowl recorded during the summer surveys has been positively correlated with lake elevation in June ($r = 0.605$, $p = 0.0284$, Figure 35) while total waterfowl diversity has not ($r = 0.461$, $p=0.113$). The number of broods detected has also been significantly, positively correlated with the lake elevation in June and July (June: $r =0.89$, $p < 0.01$) (Figure 36). The number of broods at Mono Lake in 2014 (31) was below the long-term mean of 54.1 +/- 17.3.

Fall Waterfowl

There has been no correlation between total fall waterfowl numbers and lake elevation in September ($r = -0.131$, $p =0.69$) (Figure 37), lake elevation change, nor between lake elevation and numbers of the two most abundant species, Northern Shoveler and Ruddy Duck. There has been no trend in total waterfowl use of the lake in fall for the period 2002-2014 ($r = 0.316$, $p = 0.292$).

Comparison Counts

There has been no correlation between the total waterfowl detected at Mono Lake and either Bridgeport or Crowley Reservoir, nor between the number of waterfowl detected at Bridgeport and Crowley Reservoirs. The median value of total waterfowl has been highest at Crowley Reservoir (Figure 38), as waterfowl numbers have generally been higher at Crowley than Mono Lake or Bridgeport Reservoir. Given the annual range of variability observed in total waterfowl numbers, however, no one site has supported significantly higher fall numbers. Total waterfowl observed in 2014 at all three sites was within the range observed 2002-2014.

Northern Shoveler use of Mono Lake tends to be higher (annual mean 14,162) than either Bridgeport (8,758) or Crowley Reservoirs (7,643), however this difference was not statistically significant due to annual variations in relative use over the time period 2002-2014. Fewer Ruddy Ducks use Bridgeport Reservoir than either Mono Lake or Crowley Reservoir ($F = 7.428$, $p = 0.003$). Mean annual Ruddy Duck numbers have been higher at Mono Lake than Crowley Reservoir (annual mean of 11,003 vs. 7,474), however this difference is not statistically significant due to annual variations in relative use over the time period 2002-2014.

SUMMARY

The numbers of broods seen in 2014 was the lowest seen since ground-based surveys began in 2002, and was significantly lower than the 14-year mean. Mono Lake was also at its lowest summer elevation since 1996 when the Mono Basin Waterfowl Restoration Plan was adopted. Increases in elevation, (at least within the elevation ranges observed since monitoring was initiated), result in increases in the number and extent of near-shore ponds, especially in the South Shore Lagoons area. Conversely, decreases in elevation result in the contraction in size of ponds, or the complete drying of many ponds used by waterfowl for breeding. In most shoreline areas, increases in lake elevation have been associated with changes to lake-fringing habitats that increase the quality and quantity of potential breeding habitat for waterfowl. Based on field observations, these ponds enlarge due either to increases in the groundwater table or increases in spring flow. Brooding female ducks generally select habitats that have high invertebrate populations and dense vegetative cover (Baldassarre and Bolen 1994). The near-shore ponds, when present, provide invertebrates required by ducklings for growth and development, and often dense vegetative cover nearby. Some of the fresh water ponds at Mono Lake such as those that occur at the outflow of the Goose Springs complex in the South

Shore Lagoons area, have been stable and present since at least 2002. Other ponds are ephemeral and have varied considerably in size depending on lake elevation. The breeding population of waterfowl at Mono Lake appears to respond positively to increases in pond availability as increases in brood production have been positively correlated with increases in lake elevation.

Breeding waterfowl have shown variability with regard to the proportional use of the various lake-fringing habitats, likely in response to yearly changes in habitat availability and habitat quality. The habitats in which waterfowl at Mono Lake are encountered include semi-permanent ponds, and areas that are ephemeral or highly variable in nature and extent on a yearly basis. In 2014, most waterfowl were observed using ria and freshwater ponds. Ria habitat occurs at the mouth of creeks and springs where fresh water flows into Mono Lake and is defined as the area where salt and fresh water stratification occurs. Fresh water outflow areas are areas where waterfowl are typically found feeding, brooding and resting. The availability of ria habitat likely varies yearly and seasonally with variations in runoff, creek flow, spring flow, and shoreline configuration that may divert or redirect fresh water flows. Freshwater ponds occur in the vicinity of springs or creeks and provide feeding and resting areas for waterfowl. Unvegetated areas vary from dry sandy beach to mudflats depending on whether there is spring flow in an area. Waterfowl often use unvegetated areas for loafing and sleeping, but when spring flow in an area produces mudflats, waterfowl may be found foraging on these unvegetated mudflats. Many habitats used by waterfowl at Mono Lake are ephemeral in nature. Habitat conditions are documented qualitatively through field observations during summer surveys and through annual photography of shoreline areas in the fall. Habitat conditions that may explain waterfowl use and the spatial distribution of waterfowl at Mono Lake, however are not readily quantified during existing vegetation mapping efforts conducted every five years because of their ephemeral nature, small scale, and lack of information regarding food resources associated with the various habitat resources.

The use of Mono Lake by fall migrants is much greater than by breeding waterfowl, and is dominated by two species, Northern Shoveler and Ruddy Duck. The aquatic ecosystem of Mono Lake is also dominated by few species, which is typical of highly saline systems. The open waters of Mono Lake are rich in zooplankton, phytoplankton, and benthic algae, some of which are accessible to waterfowl as a food resource. Due to the salinity of the water, the lake does not support submerged aquatics as a food resource for waterfowl. Plant food resources such as aquatic and wetland vegetation, which are an important food resource to many waterfowl species in fall, are limited to lake-fringing wetland areas, which comprise a small fraction of the total area of Mono Lake. The Northern Shoveler, unlike other dabbling duck species in the genus *Anas*, has a bill ideally suited to strain small crustaceans from the water column. Ruddy Ducks are reported to feed primarily on aquatic insects, crustaceans, zooplankton, and other invertebrates, consuming only small amounts of aquatic vegetation and seeds (Brua, 2002). Although no diet study has been conducted on waterfowl at Mono Lake, to varying extents, these species are expected to feed on brine shrimp and alkali flies that are found in abundance at Mono Lake.

At Mono Lake, Northern Shoveler tend to be encountered in large cohesive flocks in fall as was observed in 2014 also. The Wilson and Mill Creek deltas and the south shoreline areas of Sammann's Spring and South Shore Lagoons continued to the main areas of waterfowl use in fall as these areas consistently attract a large proportion of Northern Shovelers every year. Human disturbance likely explains the shift in distribution of waterfowl from the Wilson and Mill Creek delta to Perseverance Spring in the DeChambeau Embayment area observed during the mid-September survey. Human-caused disturbances have been shown to alter waterbird behavior, diverting time and energy away from other essential behaviors such as feeding (Borgmann 2010).

In 2014, total waterfowl numbers at all three sites were within the 14-year mean, although the number of waterfowl at Bridgeport Reservoir was the lowest recorded in all survey years. The level of Bridgeport Reservoir was very low in 2014 and this may at least partly explain the reduced use of this site through direct or indirect processes. The proportional abundance of waterfowl species at Mono Lake differs greatly from that of the nearby freshwater reservoirs as the fall waterfowl population at Mono Lake is dominated by Northern Shoveler and Ruddy Duck, while waterfowl populations at the reservoirs are much more diverse. Comparison counts between Mono Lake and the two fresh water reservoirs are of limited usefulness. The food resources of a fresh water reservoir little resemble those of Mono Lake, and thus waterfowl using Mono Lake encounter and are responding to a different set of environmental variables. The lack of correlation between waterfowl population numbers at Bridgeport and Crowley with Mono Lake is not surprising. In addition, the greater proportional use of Mono Lake than the nearby reservoirs by Northern Shoveler and Ruddy Ducks is also expected as these species are able to exploit available resources more effectively than other species.

Migratory waterfowl populations that use Mono Lake are expected to be influenced by a multitude of factors. Short-term and long-term population trends will be affected by conditions on breeding grounds, wintering grounds, and along migratory routes. Mono Lake provides abundant food resources for the limited number of waterfowl species that are able to exploit those resources. Important waterfowl habitats at Mono Lake such as brackish and freshwater ponds are ephemeral in nature as the shoreline configuration is dynamic, changing as a result of lake elevation changes and the effect of wind on the shoreline. The preliminary analysis conducted here indicates no direct and simple relationship between fall waterfowl populations and lake elevation or lake elevation changes.

RECOMMENDATIONS

Under the Mono Basin Implementation Plan (LADWP 2000a), the monitoring of waterfowl populations in the Mono Basin was to continue until at least the year 2014, or until the targeted lake level (6,392 foot elevation) was reached and the lake cycled through a complete wet/dry cycle. Recovery of lake elevation to the target level is taking longer than anticipated and predicted by previous models and Mono Lake has not yet reached the targeted lake elevation since implementation of the Plan. In addition, over the last five years, the lake elevation has dropped approximately 5 feet due to successive years of below-average precipitation. In 2010, Watercourse Engineering and LADWP reevaluated Mono Lake elevation predictions using a 31-year dataset (1980-2010). Based on reiterative runs of the model, the average length of time predicted for Mono Lake to reach the targeted lake level of 6,392 feet at that time was 17 years (range of 3-25 years).

Taking into consideration that the targeted lake elevation may not be reached for quite some time, it seems prudent to reevaluate the waterfowl monitoring program at this point. I recommend that a report be developed synthesizing the results of the waterfowl monitoring program to date. The report will include a comparison of lake, local and regional trends where possible, an analysis of the efficiency of the program, and the efficacy of the program at fulfilling both the requirements and intent of the Plan. Recommendations for modifications to the current program or for management of waterfowl habitat at Mono Lake will also be addressed.

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Table 1. Summary of 2014 Summer Ground Count Data

Species	Survey 1	Survey 2	Survey 3	Total	Percent Detections
Canada Goose	102	41	26	169	21.9%
Gadwall	164	178	65	407	52.7%
Mallard	57	18	7	82	10.6%
Cinnamon Teal	2	5	0	7	0.9%
Northern Shoveler	2	0	0	2	0.3%
Northern Pintail	0	0	1	1	0.1%
Green-winged Teal	12	81	6	99	12.8%
Unidentified Teal	0	0	1	1	0.1%
Ruddy Duck	1	4	0	5	0.6%
Total Waterfowl	340	327	106	773	

Table 2. 2014 Summer Ground Count Data

Table shows the total detections of each species in each shoreline area, total waterfowl detections by area, and the percent of total detections by area.

Species	DECR	LVCR	MICR	RUCR	SASP	SOTU	SSLA	WASP	WICR	**Total**
Canada Goose	87		9	20	29	21	3			169
Gadwall	44	11	99	17	26	4	84	10	112	407
Mallard	2		8	1	9	1	19	39	3	82
Cinnamon Teal				1	1		4	1		7
Northern Shoveler								2		2
Northern Pintail								1		1
Green-winged Teal	2		18	7			64		8	99
Unidentified Teal		1								1
Ruddy Duck			5							5
Total Detections	**135**	**12**	**139**	**46**	**65**	**26**	**174**	**53**	**123**	**773**
% of Detections	17.5%	1.6%	18.0%	6.0%	8.4%	3.4%	22.5%	6.9%	15.9%	

Table 3. 2014 Brood Data

Table shows the number of broods by species per shoreline survey area.

Total	Shoreline Segment	DECR	LVCR	MICR	RUCR	SASP	SOTU	SSLA	WASP	WICR	**Total**
	Canada Goose			2			1				**3**
	Gadwall	4		7		3		5		3	**22**
	Green-winged Teal			1	4						**5**
	Mallard			1							**1**
	Total broods per area	4	0	11	4	3	1	5	0	3	31

Table 4. Summary of 2014 Mono Lake Fall Aerial Survey Count Data

Species	3-Sep	16-Sep	1-Oct	16-Oct	29-Oct	12-Nov	Total detections	% Total
Greater White-fronted Goose			5				5	<0.1%
Snow Goose						7	7	<0.1%
Cackling Goose				1		5	6	<0.1%
Canada Goose	15	2	33	15	35	144	244	1.1%
Gadwall	24	7	11	3		10	55	0.3%
American Wigeon						8	8	<0.1%
Mallard	22		20	29	5	2537	2613	11.9%
Cinnamon Teal	10	8					18	0.1%
Northern Shoveler	7157	3331	398	35	35	349	11305	51.6%
Northern Pintail	5	52	60	72	23	40	252	1.2%
Green-winged Teal	9	35	30	108	115	107	404	1.8%
Unidentified Teal	30	12	57	18	210	330	657	3.0%
Redhead				6		2	8	<0.1%
Lesser Scaup				12	5		17	0.1%
Bufflehead					1	34	35	0.2%
Ruddy Duck	899	386	2255	1220	872	631	6263	28.6%
Unidentified Diving Duck						1	1	<0.1%
Total Waterfowl	8171	3833	2869	1519	1301	4205	21898	
Species Richness	**8**	**7**	**8**	**10**	**8**	**12**		

Table 5. 2014 Fall Spatial Distribution of Waterfowl at Mono Lake

Lakeshore Segment	3-Sep	16-Sep	1-Oct	16-Oct	29-Oct	12-Nov	**Mean**
BLPO	0.0%	0.3%	0.5%	0.1%	0.2%	0.0%	0.2%
BRCR	0.0%	0.2%	0.0%	1.3%	0.0%	0.0%	0.2%
DECR	0.1%	4.6%	2.5%	3.9%	1.9%	1.7%	2.5%
DEEM	1.3%	40.7%	11.3%	1.4%	5.5%	5.1%	10.9%
LVCR	0.2%	0.2%	0.1%	2.2%	1.8%	7.7%	2.0%
MICR	36.1%	6.5%	0.0%	0.0%	12.5%	12.4%	11.3%
NESH							
RACO	0.1%		0.0%	0.0%	1.5%	0.5%	0.4%
RUCR	0.0%	0.1%	0.0%	0.3%	0.7%	2.0%	0.5%
SASP	0.5%	35.5%	1.2%	2.2%	8.3%	0.6%	8.1%
SOTU	0.2%	0.0%	0.0%	1.0%	1.2%	0.0%	0.4%
SSLA	0.8%	1.2%	1.6%	4.9%	0.1%	30.2%	6.5%
WASP	0.1%	0.2%	1.6%	1.2%	3.8%	2.0%	1.5%
WESH	0.1%	0.1%	0.2%	11.2%	6.9%	0.0%	3.1%
WICR	49.6%	0.7%	4.3%	7.2%	1.0%	22.9%	14.3%
Total Shoreline	89.1%	90.2%	23.3%	36.9%	45.3%	85.1%	61.7%
Offshore	10.9%	9.8%	73.4%	61.8%	54.7%	14.9%	37.6%

Table 6. Summary of 2014 Bridgeport Reservoir Fall Aerial Survey Count Data

Species	3-Sep	16-Sep	1-Oct	16-Oct	29-Oct	12-Nov	Total detections	% Total
Snow Goose						6	6	<0.1%
Canada Goose	500	420	395	452	550	940	3257	24.8%
Tundra Swan						22	22	0.2%
Gadwall	52	25	20	502	70	300	969	7.4%
American Wigeon					80		80	0.6%
Mallard	77		238	346	200	500	1361	10.4%
Northern Shoveler	816	1170	1033	784	400	60	4263	32.5%
Northern Pintail		20	105	103	175	600	1003	7.6%
Green-winged Teal	500	151	60		50	80	841	6.4%
Unidentified Teal			20	5			25	0.2%
Canvasback						10	10	0.1%
Redhead					40		40	0.3%
Ring-necked Duck						20	20	0.2%
Lesser Scaup				6	20		26	0.2%
Bufflehead				3	25	41	69	0.5%
Common Merganser	9	56		25		1	91	0.7%
Ruddy Duck	70	120	45	22	746	3	1006	7.7%
Unidentified Diving Duck				30			30	0.2%
Total Waterfowl	2024	1962	1916	2278	2356	2583	13119	
Species Richness	7	7	7	9	11	13		

Table 7. 2014 Fall Spatial Distribution of Waterfowl at Bridgeport Reservoir

Lakeshore Segment	3-Sep	16-Sep	1-Oct	16-Oct	29-Oct	12-Nov	**Mean**
EASH	0.5%	0.7%	32.3%	0.6%	8.0%	0.0%	7.0%
NOAR	2.2%	4.1%	6.6%	10.0%	0.7%	0.2%	4.0%
WEBA	97.3%	95.2%	61.1%	89.4%	91.3%	99.8%	89.0%

Table 8. Summary of 2014 Crowley Reservoir Fall Aerial Survey Count Data

Species	3-Sep	16-Sep	1-Oct	16-Oct	29-Oct	12-Nov	Total detections	% Total
Greater White-fronted Goose		15					15	<0.1%
Canada Goose	155	200	25	70	30	251	731	0.9%
Tundra Swan						8	8	<0.1%
Gadwall	300	1100	3248	677	590	530	6445	7.9%
American Wigeon	5	30	95	105		392	627	0.8%
Mallard	235	1002	2464	4367	2220	3211	13499	16.5%
Blue-winged Teal				3			3	<0.1%
Cinnamon Teal	100	20		4			124	0.2%
Northern Shoveler	5177	6279	4864	260		625	17205	21.0%
Northern Pintail	548	722	1671	1600	3380	1880	9801	12.0%
Green-winged Teal	837	970	489	1777	1707	1895	7675	9.4%
Unidentified Teal			120	10	35	5	170	0.2%
Canvasback				2	20	60	82	0.1%
Redhead			28	12		99	139	0.2%
Ring-necked Duck			4	12		20	36	<0.1%
Lesser Scaup					30	78	108	0.1%
Bufflehead	3		4	32	172	646	857	1.0%
Common Merganser		1		74			75	0.1%
Ruddy Duck	30	1084	4645	4795	7388	6464	24406	29.8%
Total Waterfowl	7390	11423	17657	13800	15572	16164	82006	
Species Richness	10	11	11	15	9	14		

Table 9. 2014 Fall Spatial Distribution of Waterfowl at Crowley Reservoir

Lakeshore Segment	3-Sep	19-Sep	1-Oct	16-Oct	29-Oct	12-Nov	**Mean**
CHCL	0%	0%	0%	1%	1%	14%	2.7%
HIBA	4%	1%	3%	1%	1%	4%	2.1%
LASP	1%	0%	3%	1%	4%	5%	2.1%
MCBA	82%	81%	66%	78%	80%	63%	75.1%
NOLA	0%	0%	1%	0%	0%	1%	0.4%
SAPO	0%	0%	1%	0%	0%	2%	0.5%
UPOW	14%	17%	26%	19%	14%	11%	17.1%

Table 10. Mono Lake Restoration Ponds - Total Summer Detections

Species	COPOE	COPOW	DEPO_1	DEPO_2	DEPO_3	DEPO_4	DEPO_5	Total
Gadwall	6			2	3	3		14
American Wigeon	1							1
Mallard	1							1
Cinnamon Teal	2			1				3
Northern Pintail	1							1
Green-winged Teal	2							2
Ruddy Duck	7			4	4	4		19
Pond Totals	20	0	0	7	7	7	0	41

Table 11. Mono Lake Restoration Ponds - Total Waterfowl Broods

Species	County Ponds	DeChambeau Ponds
Gadwall	4	
Cinnamon Teal		1
Ruddy Duck	1	2
Total Broods	5	3

Table 12. Mono Lake Restoration Ponds - 2014 Fall Survey Counts

County Ponds	**3-Sep**	**19-Sep**	**1-Oct**	**15-Oct**	**29-Oct**	**12-Nov**	Total Fall Detections
Tundra Swan						3	3
Gadwall					6	6	12
Mallard				8		20	28
Unidentified Teal					2	40	42
Total Waterfowl	0	0	0	8	8	69	85

DeChambeau Ponds	**3-Sep**	**19-Sep**	**1-Oct**	**15-Oct**	**29-Oct**	**12-Nov**	Total Fall Detections
Gadwall	5	10			2	3	20
Northern Shoveler			2	2			4
Unidentified Teal			4				4
Total Waterfowl	5	10	6	2	2	3	28

Figure 1. Summer Ground Count Survey Areas

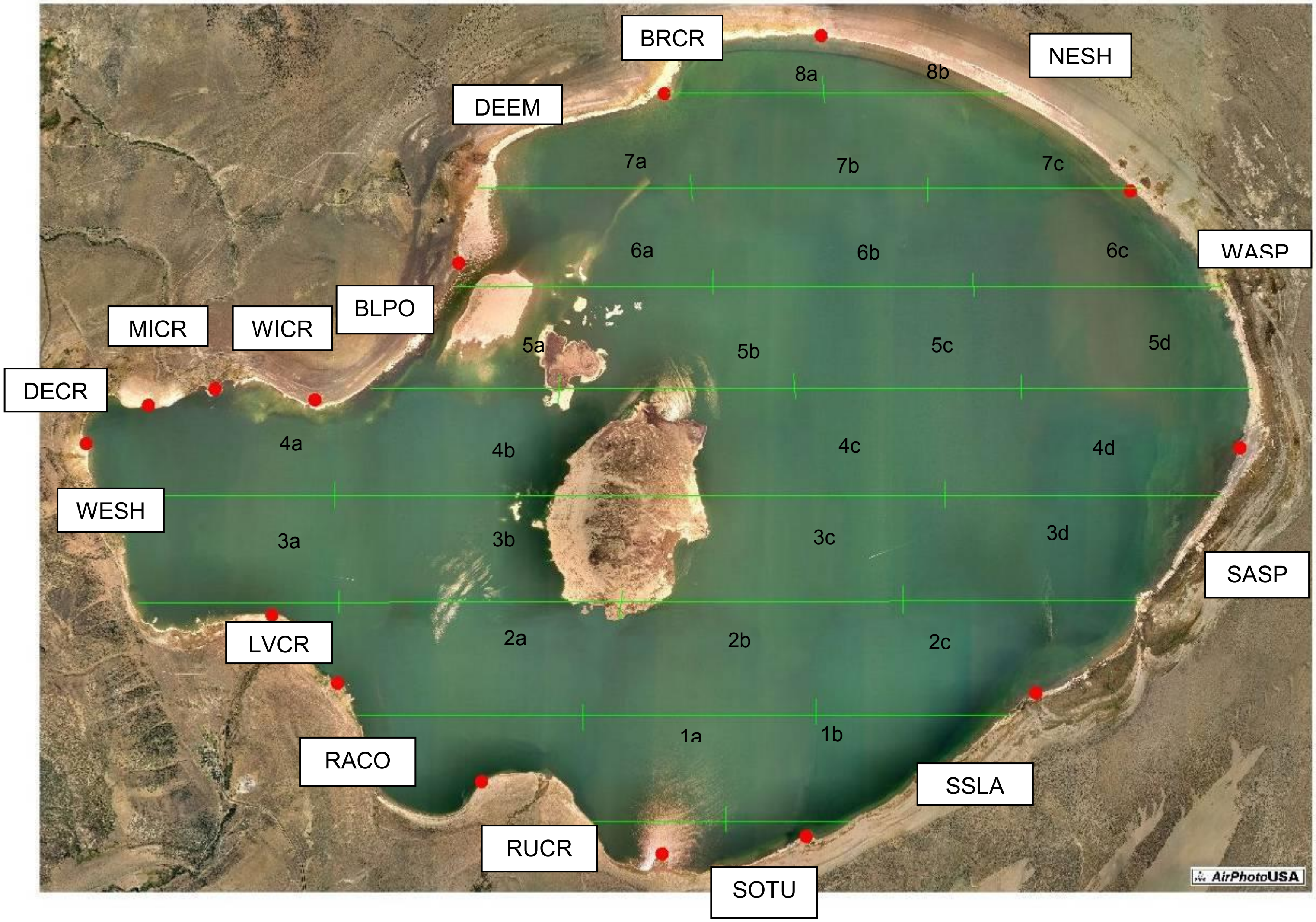

Figure 2. Mono Lake Fall Aerial Survey Lakeshore Segments, Boundaries, and Cross-Lake Transects

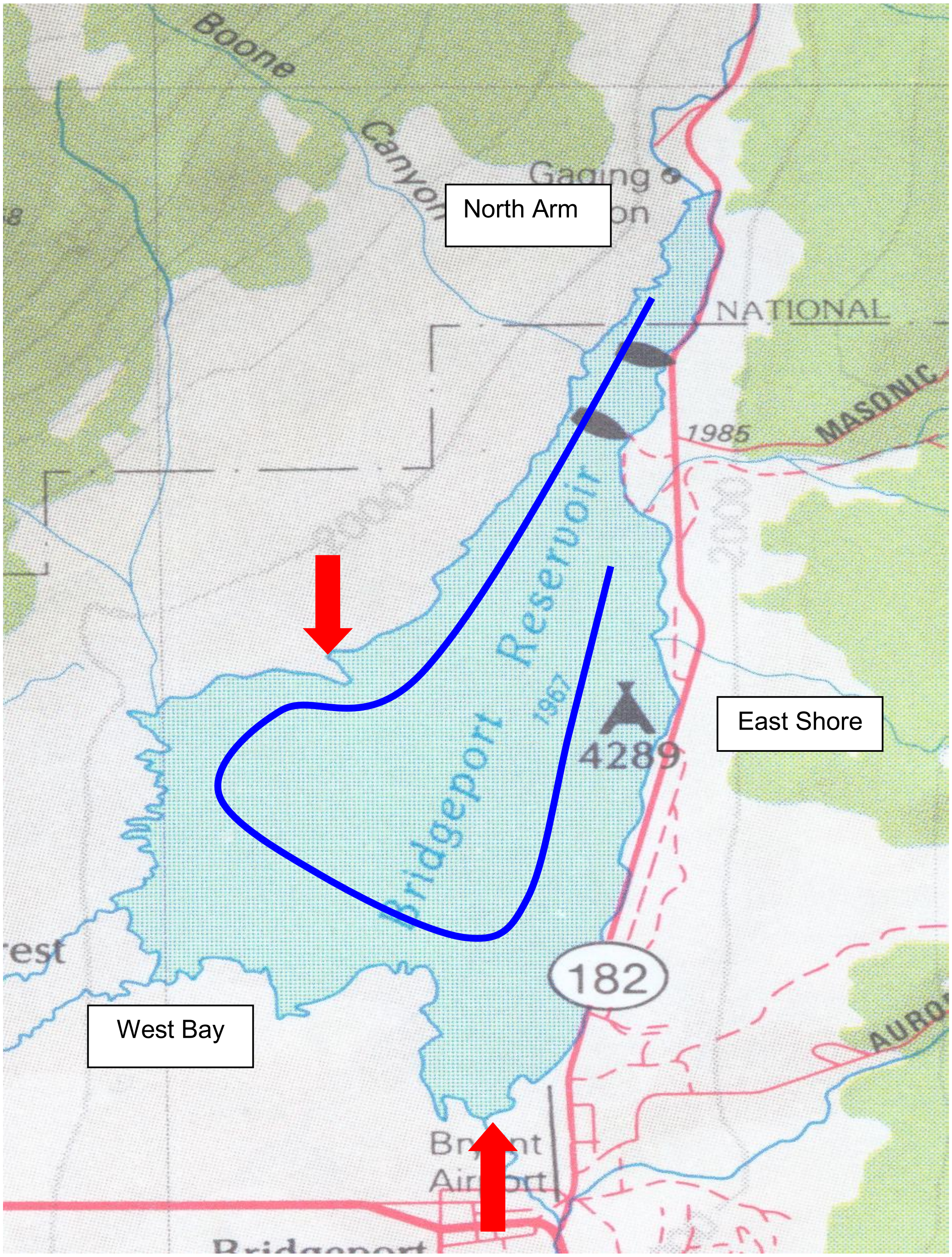

Figure 3. Bridgeport Reservoir Lakeshore Segments and Segment Boundaries

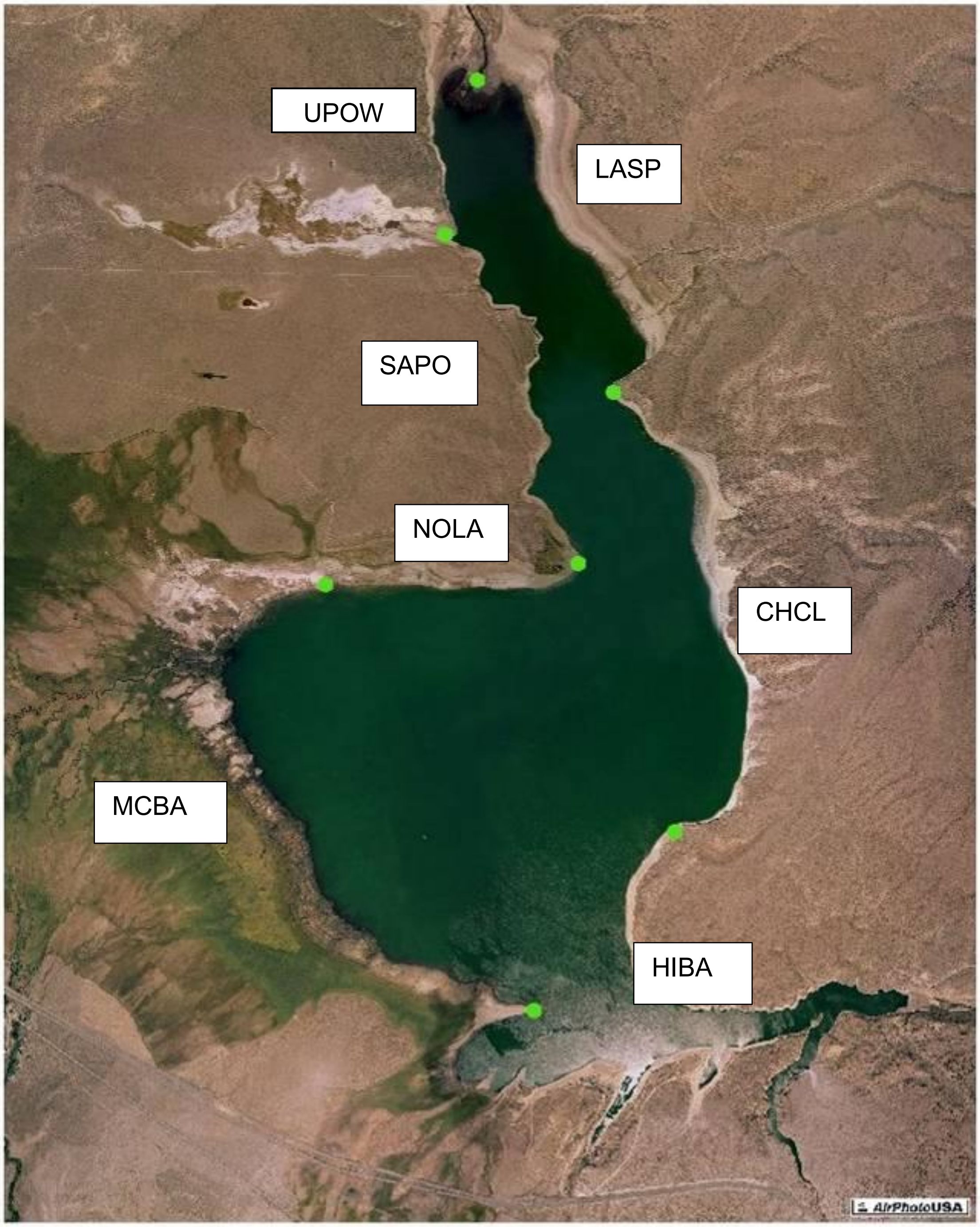

Figure 4. Crowley Reservoir Lakeshore Segments and Segment Boundaries

Figure 5. South Tufa Shoreline Area

Figure 6. South Shore Lagoons Area – First Pond

Figure 7. South Shoreline – Sand Flat Spring

Figure 8. South Shore Lagoons Shoreline Area

Figure 9. South Shore Lagoons Goose Springs Outflow Area

Figure 10. Sammann's Spring West of Tufa Grove

Figure 11. Sammann's Spring, east of Tufa grove

Figure 12. Warm Springs

Figure 13. Northeast Shore

Figure 14. Bridgeport Creek Shoreline Area

Figure 15. DeChambeau Embayment – Perseverence Spring

Figure 16. Black Point

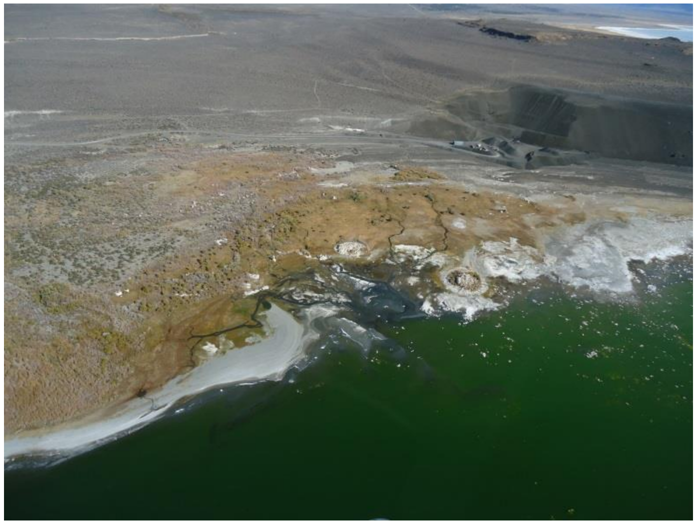

Figure 17. Wilson Creek Shoreline Area

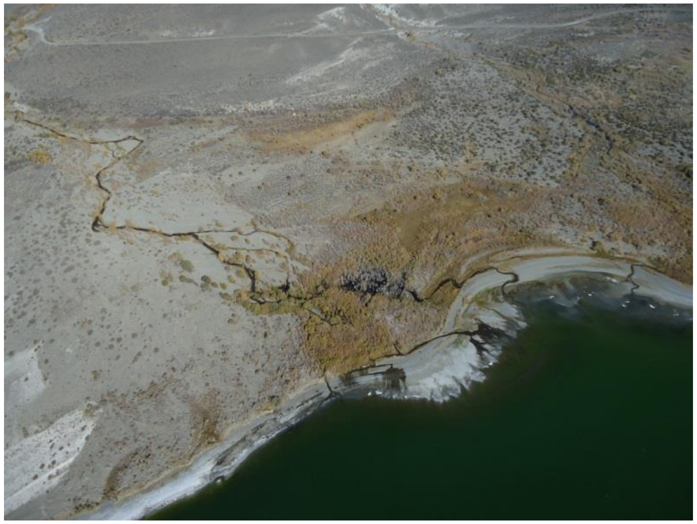

Figure 18. Mill Creek Delta

Figure 19. DeChambeau Creek Shoreline Area

Figure 20. West Shore

Figure 21. Lee Vining Creek Delta

Figure 22. Ranch Cove Shoreline Area

Figure 23. Rush Creek Delta

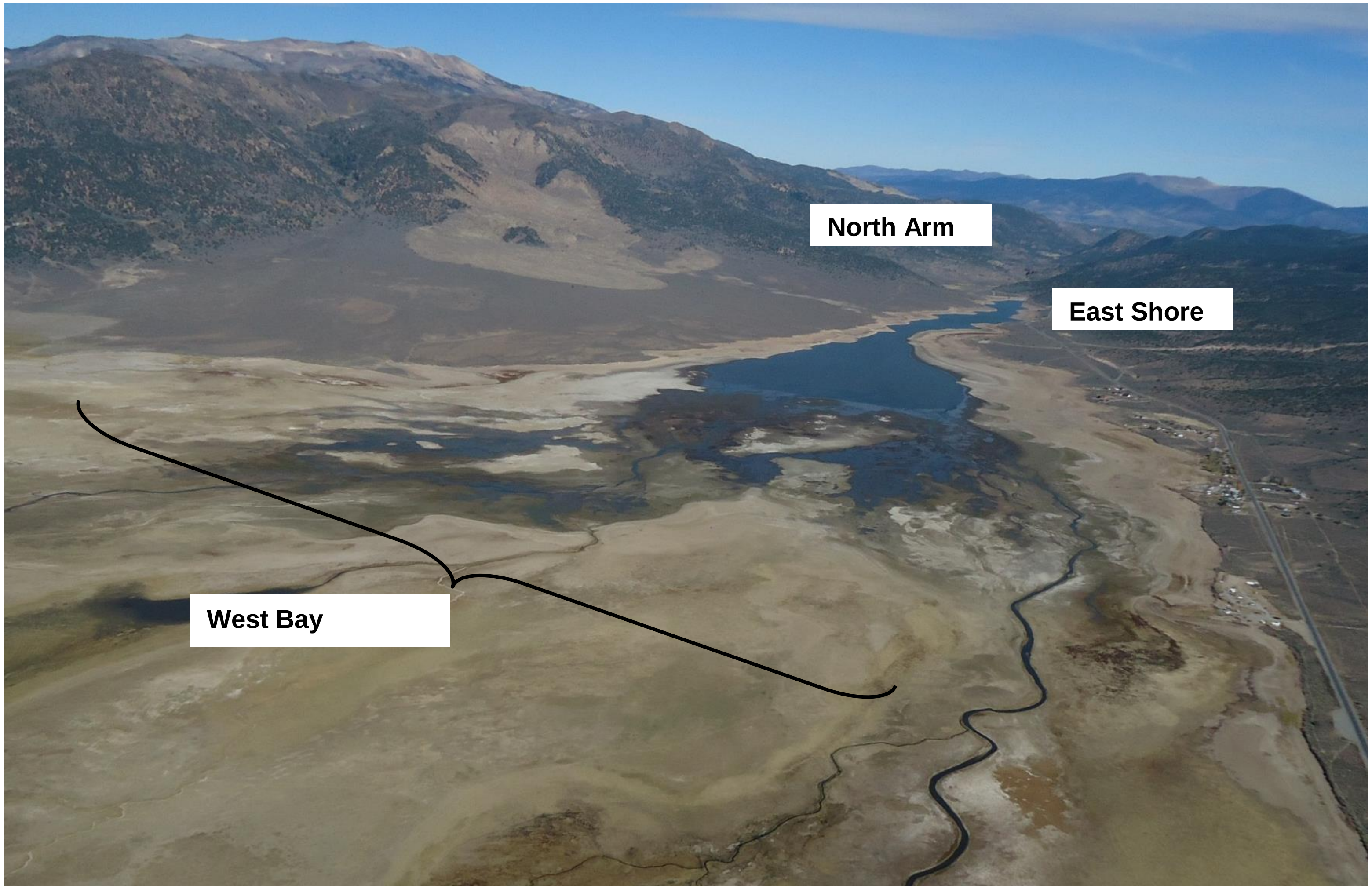

Figure 24. Photo of Bridgeport Reservoir, Looking North
Photo shows the West Bay area and the south end of the East Shore area. The majority of waterfowl that use Bridgeport Reservoir in the fall congregate in this southern end of the reservoir.

Figure 25. Crowley- Upper Owens River Delta

Figure 26. Crowley -Sandy Point Shoreline Area

Figure 27. Crowley -North Landing Shoreline Area

Figure 28. Crowley - McGee Bay

Figure 29. Crowley -Hilton Bay

Figure 30. Crowley - Chalk Cliffs

Figure 31. Crowley - Layton Springs

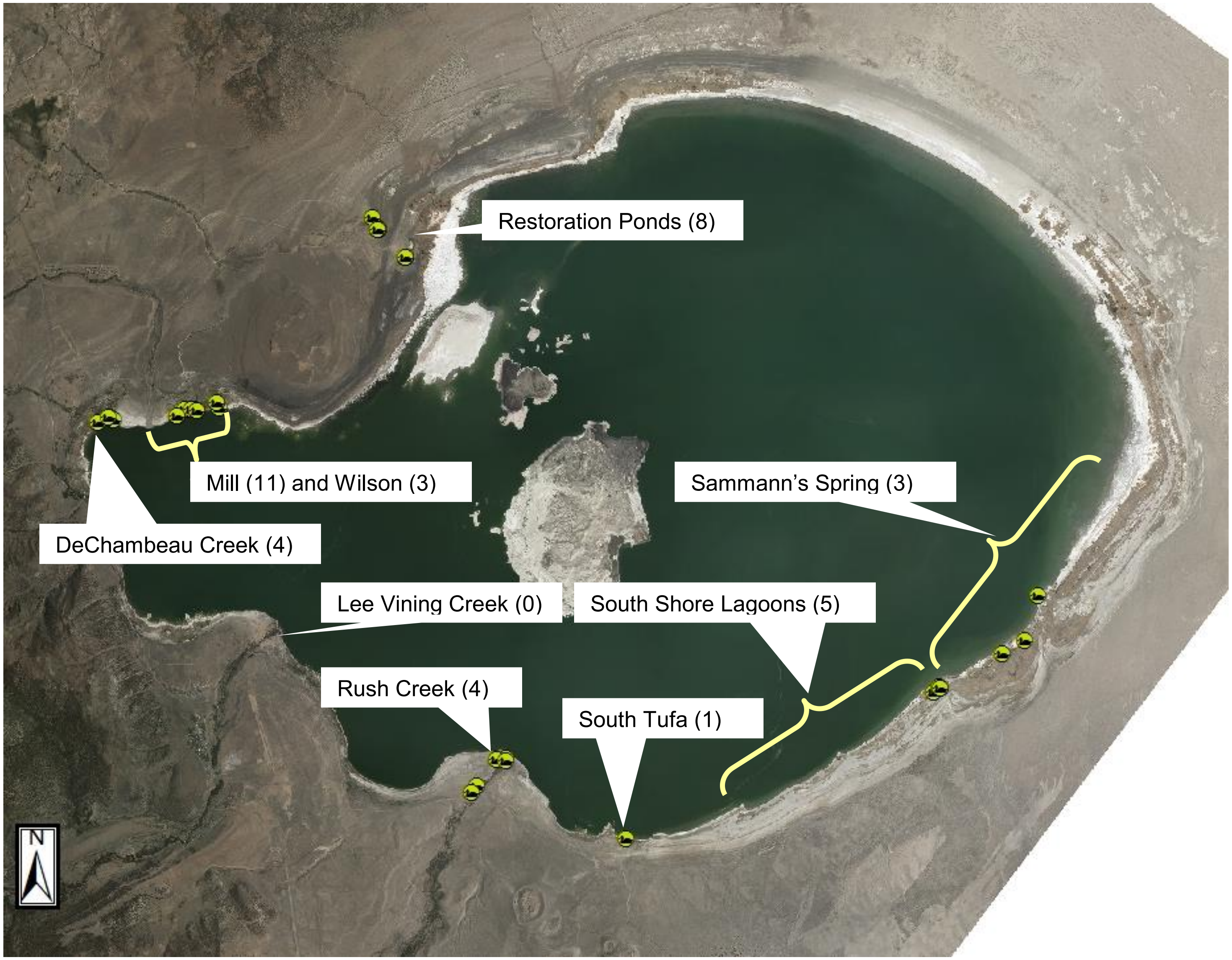

Figure 32. 2014 Brood Locations
The number in parentheses indicates the number of broods found in each area.

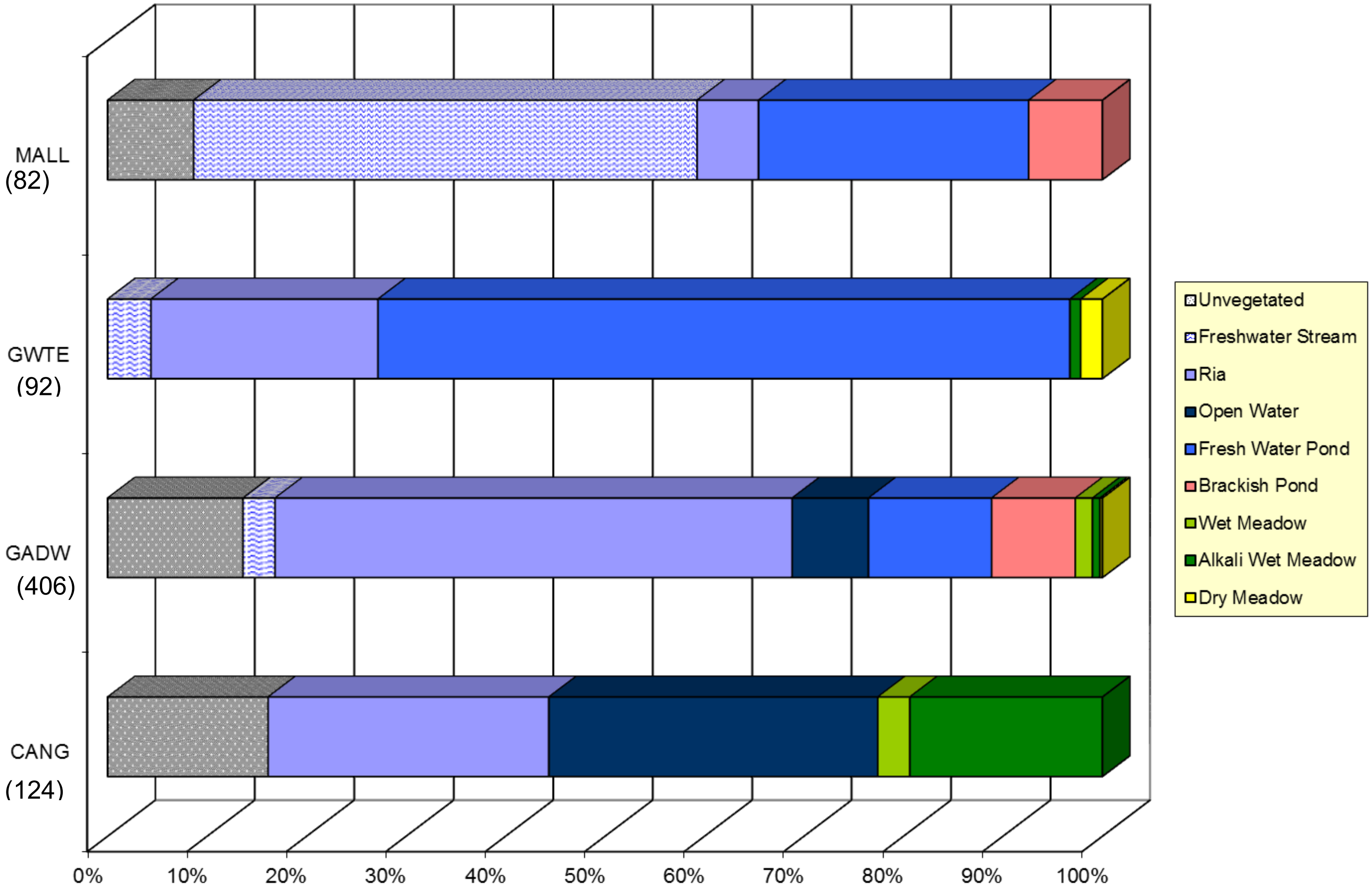

Figure 33. Waterfowl Habitat Use
The numbers in parentheses indicate sample size. The bars represent the percent of the total observations.

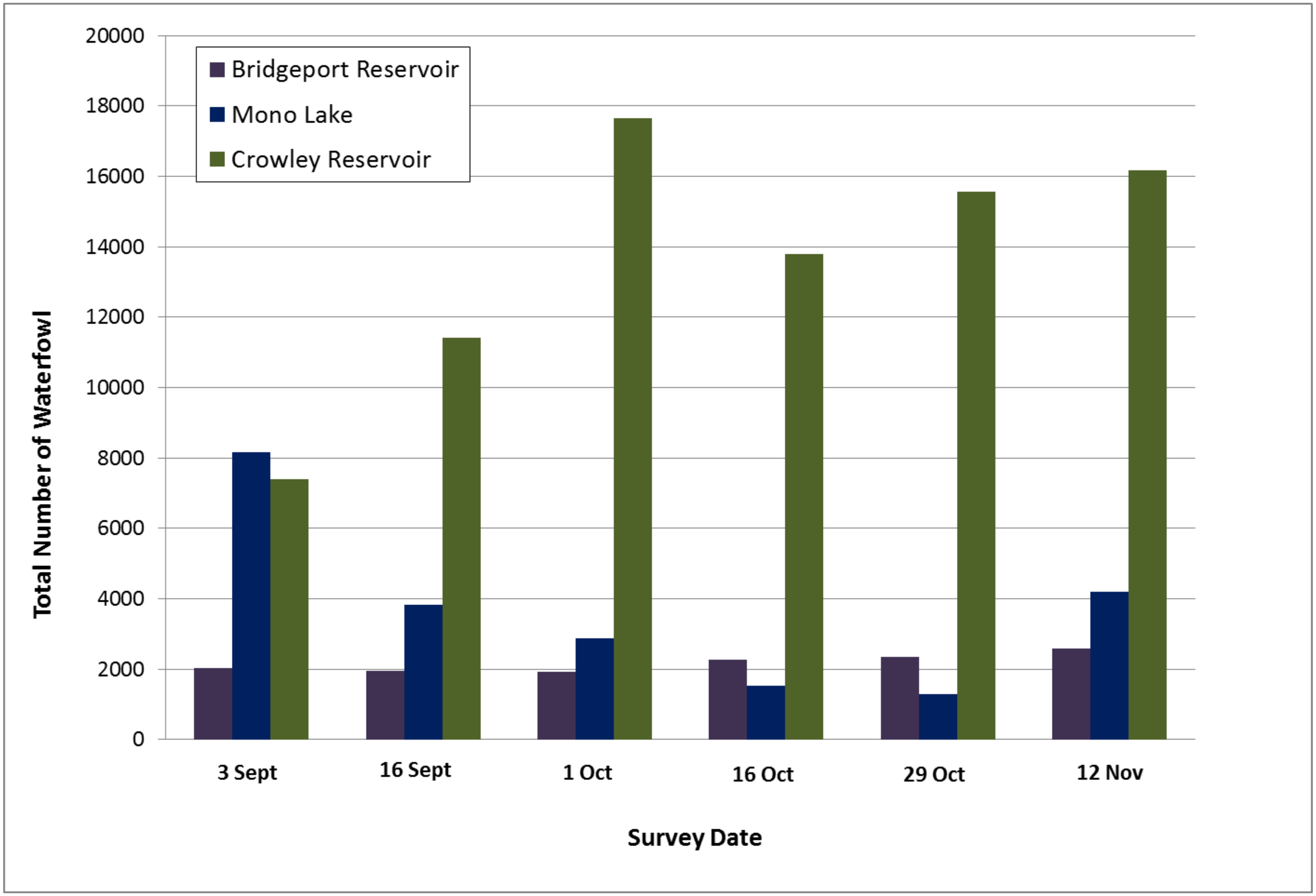

Figure 34. Total Fall Detections by Waterbody

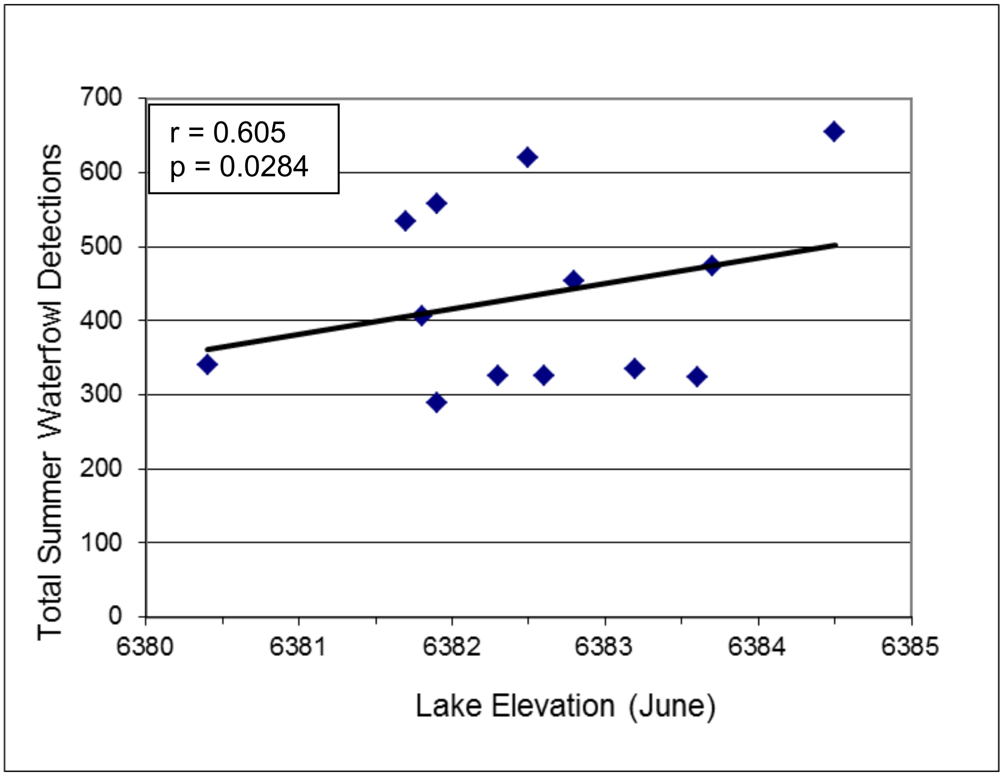

Figure 35. Relationship Between Total Waterfowl and Lake Elevation in June

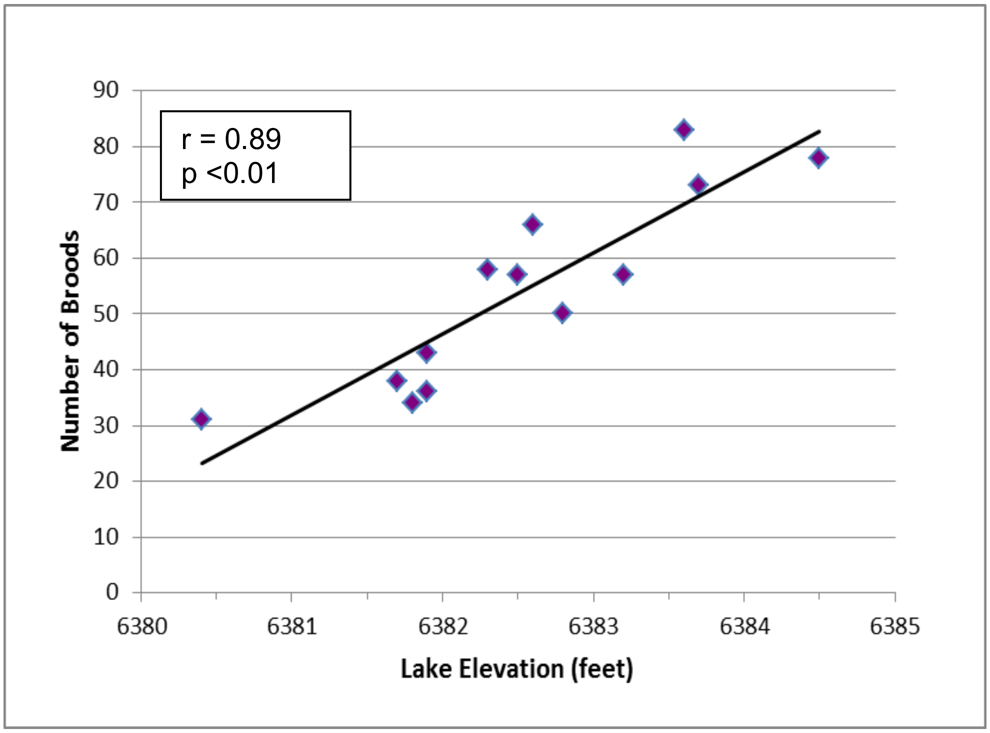

Figure 36. Relationship Between Total Broods and Lake Elevation in June

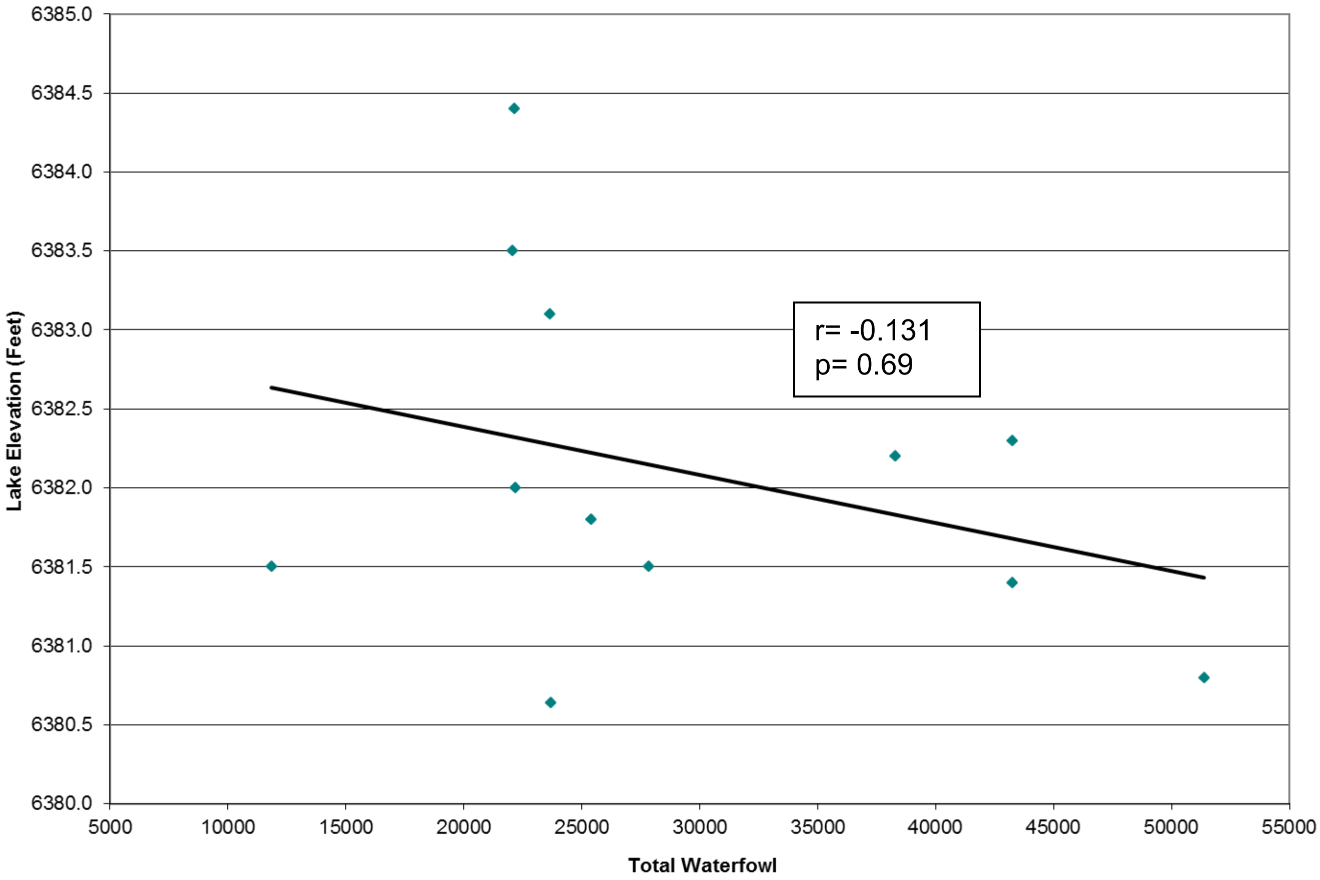

Figure 37. Relationship between Total Fall Waterfowl and Lake Elevation in September – Mono Lake

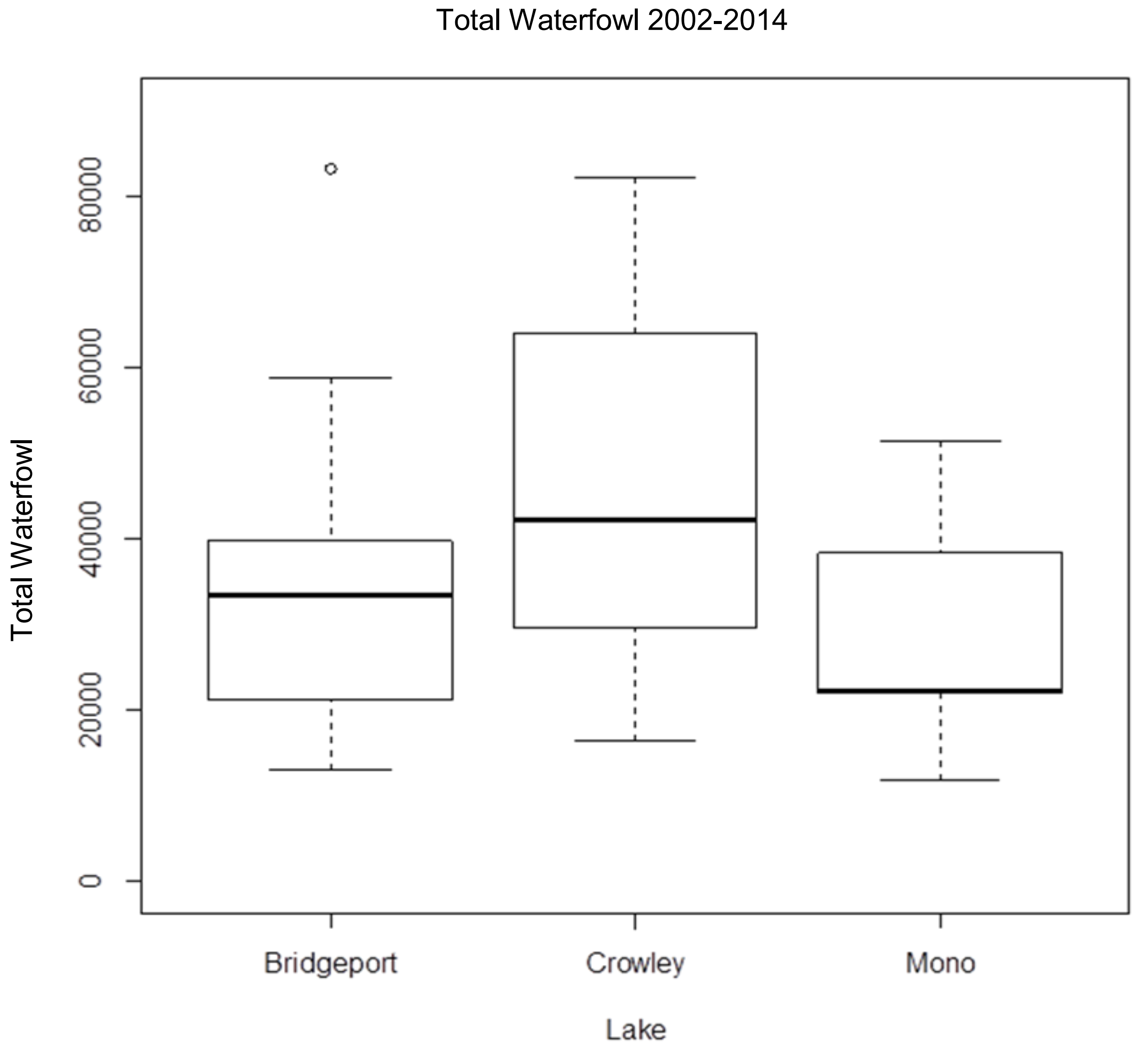

Figure 38. Box-plot Diagram of Total Fall Waterfowl Numbers - 2002-2014. Graph portrays the highest and lowest values for each site, and the dark bars represent the median values. Only one outlier exists for this time period (Bridgeport in fall 2005).

APPENDICES

Appendix 1. 2014 Ground Count Survey Dates and Times

Survey 1

Survey Area	Survey Date and Time			
	2-Jun	3-Jun	4-Jun	5-Jun
RUCR	0547 - 0705 hrs			
SOTU	0758-0929 hrs			
SSLA	0930 - 1240 hrs	1141 - 1442 hrs		
DECR		0549 - 0655 hrs		
MICR		0655 - 0815 hrs		
WICR		0815 - 0916 hrs		
LVCR		1229 - 1350 hrs		
DEPO		1059-1120 hrs		
COPO		1120-1133 hrs		
SASP			0615 - 1030 hrs	
WASP				0700 - 1015 hrs

Survey 2

Survey Area	Survey Date and Time			
	23-Jun	24-Jun	25-Jun	26-Jun
RUCR	1217 - 1330 hrs			
SOTU	0554 - 0653 hrs			
SSLA	0655 - 0930 hrs			
DECR		0549 - 0650 hrs		
MICR		0657 - 0817 hrs		
WICR		0817 - 0855 hrs		
LVCR		1138 - 1208 hrs		
DEPO		1050 - 1110 hrs		
COPO		1020 - 1045 hrs		
SASP			0730 - 1110 hrs	
WASP				0733 - 1032 hrs

Survey 3

Survey Area	Survey Date and Time			
	14-Jul	15-Jul	16-Jul	17-Jul
RUCR				0553 - 0710 hrs
SOTU			1143 - 1216 hrs	
SSLA				0825 - 1008 hrs
DECR			0550 - 0700 hrs	
MICR			0700 - 0812 hrs	
WICR			0812 - 0856 hrs	
LVCR			1030 - 1105 hrs	
DEPO	1314 - 1340 hrs			
COPO	1345 - 1355 hrs			
SASP	0705 - 1050 hrs			
WASP		0650 - 0939 hrs		

Appendix 2. Common and Scientific Names for Species Referenced in the Document.

Common Name	Scientific Name
Greater White-fronted Goose	*Anser albifrons*
Snow Goose	*Chen caerulescens*
Cackling Goose	*Branta hutchinsii*
Canada Goose	*Branta canadensis*
Tundra Swan	*Cygnus columbianus*
Gadwall	*Anas strepera*
American Wigeon	*Anas americana*
Mallard	*Anas platyrhynchos*
Blue-winged Teal	*Anas discors*
Cinnamon Teal	*Anas cyanoptera*
Northern Shoveler	*Anas clypeata*
Northern Pintail	*Anas acuta*
Green-winged Teal	*Anas crecca*
Unidentified Teal	*Anas* (spp.)
Canvasback	*Aythya valisineria*
Redhead	*Aythya americana*
Ring-necked Duck	*Aythya collaris*
Lesser Scaup	*Aythya affinis*
Bufflehead	*Bucephala albeola*
Common Merganser	*Mergus merganser*
Red-breasted Merganser	*Mergus serrator*
Ruddy Duck	*Oxyura jamaicensis*

Appendix 3. Habitat Categories Used for Documenting Use by Waterfowl Species (from 1999 Mono Basin Habitat and Vegetation Mapping, Los Angeles Department of Water and Power 2000).

Marsh

Areas with surface water usually present all year and dominated by tall emergent species such as hard-stem bulrush (*Scirpus acutus*), cattail (*Typhus latifolia*), three-square (*Scirpus pungens*), alkali bulrush (*Scirpus maritimus*) and beaked sedge (*Carex utriculata*).

Wet Meadow

Vegetation with seasonally or permanently wet ground dominated by lower stature herbaceous plant species, such as sedges (*Carex* spp.), rushes (*Juncus* spp.), spikerushes (*Eleocharis* spp.), and some forbs (e.g. monkey flower [*Mimulus* spp.], paintbrush [*Castilleja exilis*]). Wet meadow vegetation was in areas where alkaline or saline soils did not appear to be present. This class included the “mixed marsh” series from Jones and Stokes 1993 mapping.

Alkaline Wet Meadow

This type was similar in stature to the wet meadow class but occurred in areas clearly affected by saline or alkaline soils. Vegetation was typically dominated by dense stands of Nevada bulrush (*Scirpus nevadensis*), Baltic rush (*Juncus balticus*), and/or saltgrass (*Distichlis spicata*). The high density and lushness of the vegetation indicated that it had a relatively high water table with at least seasonal inundation and distinguished it from the dry meadow vegetation class.

Dry meadow/forb

This vegetation class included moderately dense to sparse (at least 15 percent) cover of herbaceous species, including a variety of grasses and forbs and some sedges (e.g. *Carex douglasii*). As with the alkaline wet meadow type above, comparison to vegetation series in Jones and Stokes (1993) was sometimes problematic due to difficulty in distinguishing dry meadow from wet meadow types.

Riparian and wetland scrub

Areas dominated by willows (*Salix* spp.) comprised most of the vegetation classified as riparian.wetlands scrub. Small amounts of buffalo berry (*Shepardia argentea*) and Wood’s rose (*Rosa woodsii*) usually mixed with willow also were included in this class.

Great Basin scrub

Scattered to dense stands of sagebrush (*Artemisia tridentata*), rabbitbrush (*Chrysothamnus nauseosus*), and/or bitterbrush (*Purshia tridentata*) were classified as Great Basin scrub. This vegetation type included a range of soil moisture conditions, as rabbitbrush was often found in moist areas close to the lakeshore and sagebrush was typically in arid upland areas.

Riparian forest and woodland

Aspen (*Populus tremuloides*) and black cottonwood (*Populus trichocarpa*) were the two tree species most common in the riparian forest/woodland vegetation type.

Freshwater-stream

Freshwater-stream habitats are watered; freshwater channels such as exist in Rush Creek and Lee Vining Creeks.

Freshwater-ria

Freshwater-ria areas were surface water areas at the mouths of streams that likely have some salt/freshwater stratification.

Freshwater-pond

This type included ponds fed by springs within marsh areas or artificially by diversions from streams (e.g. DeChambeau/County ponds).

Ephemeral Brackish Pond

Ponds along the shoreline created by the formation of littoral bars with an extensive area of marsh or wet meadow indicating the presence of springs was present landward, were identified as ephemeral brackish ponds. In some cases, ponds were not completely cut off from lake water, but were judged to still have brackish water due to freshwater input and reduced mixing.

Ephemeral Hypersaline Pond

Ponds along the shoreline created by the formation of littoral bars, but without an extensive area of marsh or wet meadow present landward, were identified as ephemeral hypersaline ponds. These were presumed to contain concentrated brine due to evaporation.

Unvegetated

Unvegetated areas were defined as those that were barren to sparsely vegetated (<15 percent cover). This class included sandy areas, alkaline flats, tufa, and delta outwash deposits.

Appendix 4. 2014 Fall Aerial Survey Dates

Survey Number	**1**	**2**	**3**	**4**	**5**	**6**
Mono Lake	3-Sep	16-Sep	1-Oct	16-Oct	29-Oct	12-Nov
Bridgeport Reservoir	3-Sep	16-Sep	1-Oct	16-Oct	29-Oct	12-Nov
Crowley Reservoir	3-Sep	16-Sep	1-Oct	16-Oct	29-Oct	12-Nov

Appendix 5. Lakeshore Segment Boundaries

(UTM, Zone 11, NAD 27, CONUS)

Mono Lake	**Lakeshore Segment**	**Code**	**Easting**	**Northing**
	South Tufa	SOTU	321920	4201319
	South Shore Lagoons	SSLA	324499	4201644
	Sammann’s Spring	SASP	328636	4204167
	Warm Springs	WASP	332313	4208498
	Northeast Shore	NESH	330338	4213051
	Bridgeport Creek	BRCR	324773	4215794
	DeChambeau Embayment	DEEM	321956	4214761
	Black Point	BLPT	318252	4211772
	Wilson Creek	WICR	315680	4209358
	Mill Creek	MICR	313873	4209544
	DeChambeau Creek	DECR	312681	4209246
	West Shore	WESH	315547	4208581
	Lee Vining Creek	LVCR	314901	4205535
	Ranch Cove	RACO	316077	4204337
	Rush Creek	RUCR	318664	4202603
Crowley Reservoir				
	Upper Owens	UPOW	346150	4168245
	Sandy Point	SAPO	345916	4167064
	North Landing	NOLA	346911	4164577
	McGee Bay	MCBA	345016	4164414
	Hilton Bay	HIBA	346580	4161189
	Chalk Cliff	CHCL	347632	4162545
	Layton Springs	LASP	347177	4165868
Bridgeport Reservoir				
	North Arm	NOAR	306400	4244150
	West Bay	WEBA	304100	4240600
	East Shore	EASH	305600	4237600

Appendix 6. Mono Lake Cross-Lake Transect Positions

Cross-Lake Transect Number	**Latitude**
1	37º 57’00”
2	37º 58’00”
3	37º 59’00”
4	38º 00’00”
5	38º 01’00”
6	38º 02’00”
7	38º 03’00”
8	38º 04’00”

2014
MONO LAKE RIPARIAN AND LAKE FRINGING WETLAND VEGETATION MONITORING REPORT

Prepared by:

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Los Angeles Department of Water and Power

Bishop, CA.

Prepared for: State Water Resources Control Board

March 2015

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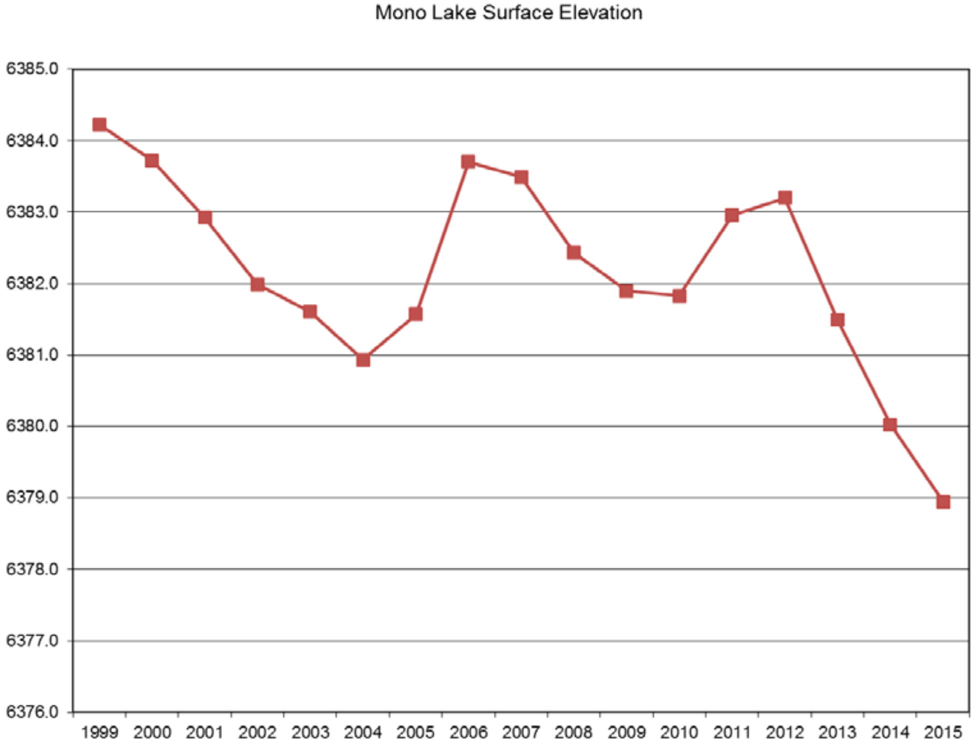
Mono Lake Vegetation Monitoring

The Los Angeles Department of Water and Power conducted vegetation-monitoring activities in lake fringing wetlands surrounding Mono Lake and in tributary stream deltas during the 2014 growing season. These efforts were undertaken to fulfill State Water Resources Control Board obligations as directed in Decision 1631 and Order No. 98-05. The objective of this monitoring effort is to determine changes to wetland communities with fluctuations in lake elevation. As of August 2014, the lake level was approximately 6,379 feet compared to 6,384 feet in 1999 when monitoring was initiated (Figure 1).

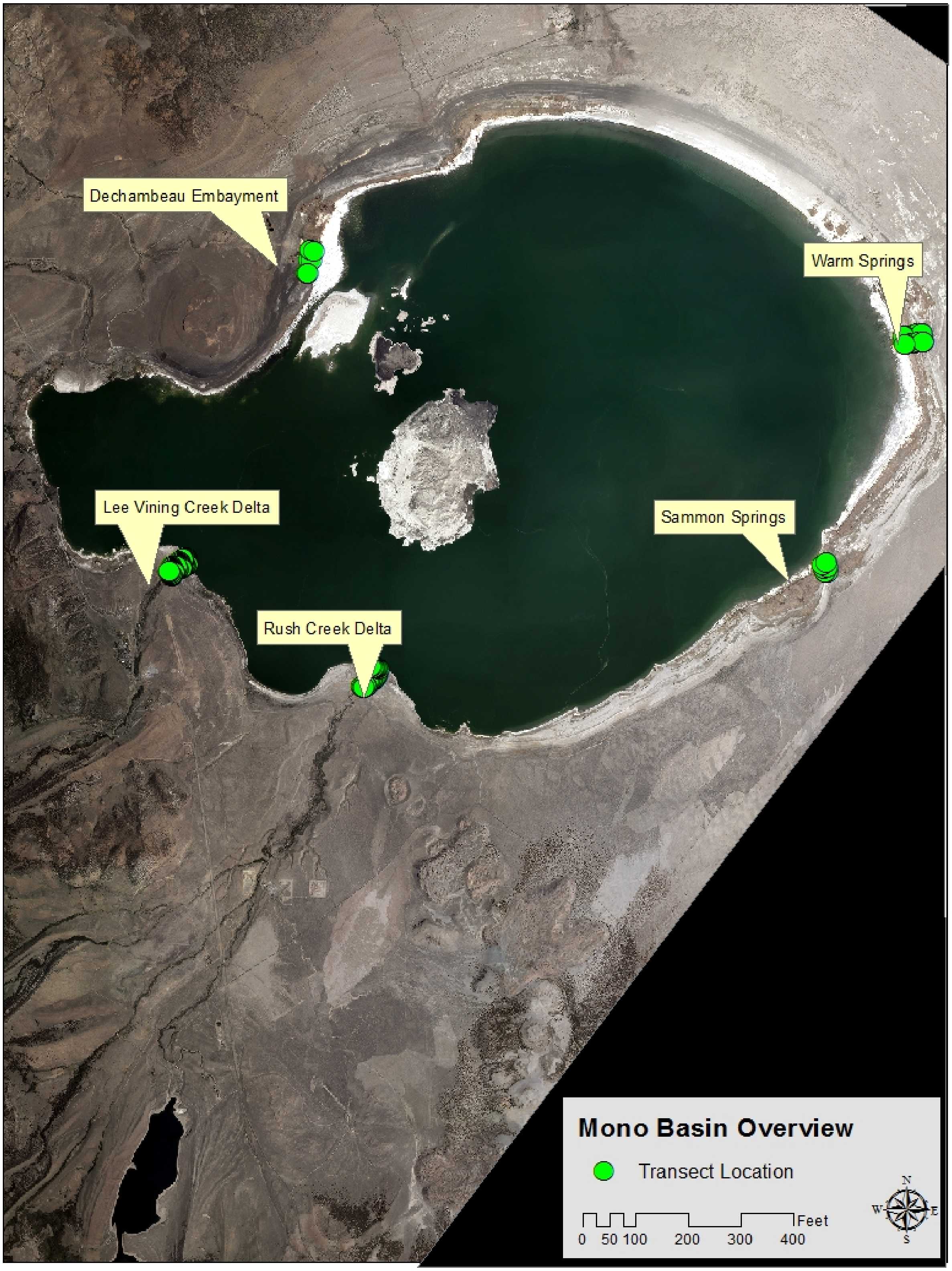
Figure 1: Mono Lake Surface Elevation



Wetland Monitoring

Wetland monitoring sites were established in 1999 at three locations in the Mono Lake Basin; Dechambeau Embayment, Warm Springs, and Sammon Springs (Figure 2). Vegetation monitoring was conducted along permanent transects using the point intercept method to determine species composition and cover for each site (Mueller et al. 2002). Caution was taken to minimize disturbance to existing vegetation along the permanent transects. Horizontal coordinates of each monitoring site and permanent transects were determined with GPS. Photographs were taken for the monitoring transects and are attached in Appendix 1.

Figure 2. Overview Map of the Mono Basin.



Vegetation Monitoring Sites

Dechambeau Embayment

At Dechambeau Embayment, three permanent transects were randomly established parallel to the Mono Lake shoreline within the marsh areas extending approximately 100 meters from the current lake shore in 1999 (Figure 3). At each end, and the mid-point of each permanent transect, three 50 m long sampling transects were established. The bearing of each sampling transect was set randomly either north or south from each sampling point during the first sampling year. The same bearings have been used in subsequent sampling years. Average cover and species composition are presented in Table 1 as the average of the sampling points of approximately equal distance from the lake shore. Sampling was conducted on August 21th 2014.

Warm Springs

At Warm Springs, six permanent transects were established parallel to the Mono Lake shoreline in 1999 (Figure 4). Transects were randomly located within the marsh areas at each site. Transects extended from the 1999 lake elevation, 6384 feet, to approximately 6392 feet (~ 550 m*)*. At 100 m intervals along each permanent transect, three 50 meter long sampling transects were established parallel to the lake shore. Sampling transects ran either north or south from the permanent transect. The direction was randomly chosen in 1999 and has remained the same. Average cover and species composition are presented in Table 2. Values are averages of the three sampling points of approximately equal distance from the lake shore. Sampling was conducted August 27-28, 2014.

Sammon Springs

At Sammon Springs, three transects established by California State Parks biologists in 1999 were utilized to determine species composition and cover in order to minimize the number of permanent markers visible at this popular tufa viewing site (Figure 5). Transects varied in length as Transects 1 and 2 are 100 meters long while Transect 3 is 75 meters long. Average cover and species composition are presented in Table 3. Sampling was conducted on August 28th 2014.

Figure 3. Dechambeau Embayment Transect Locations.

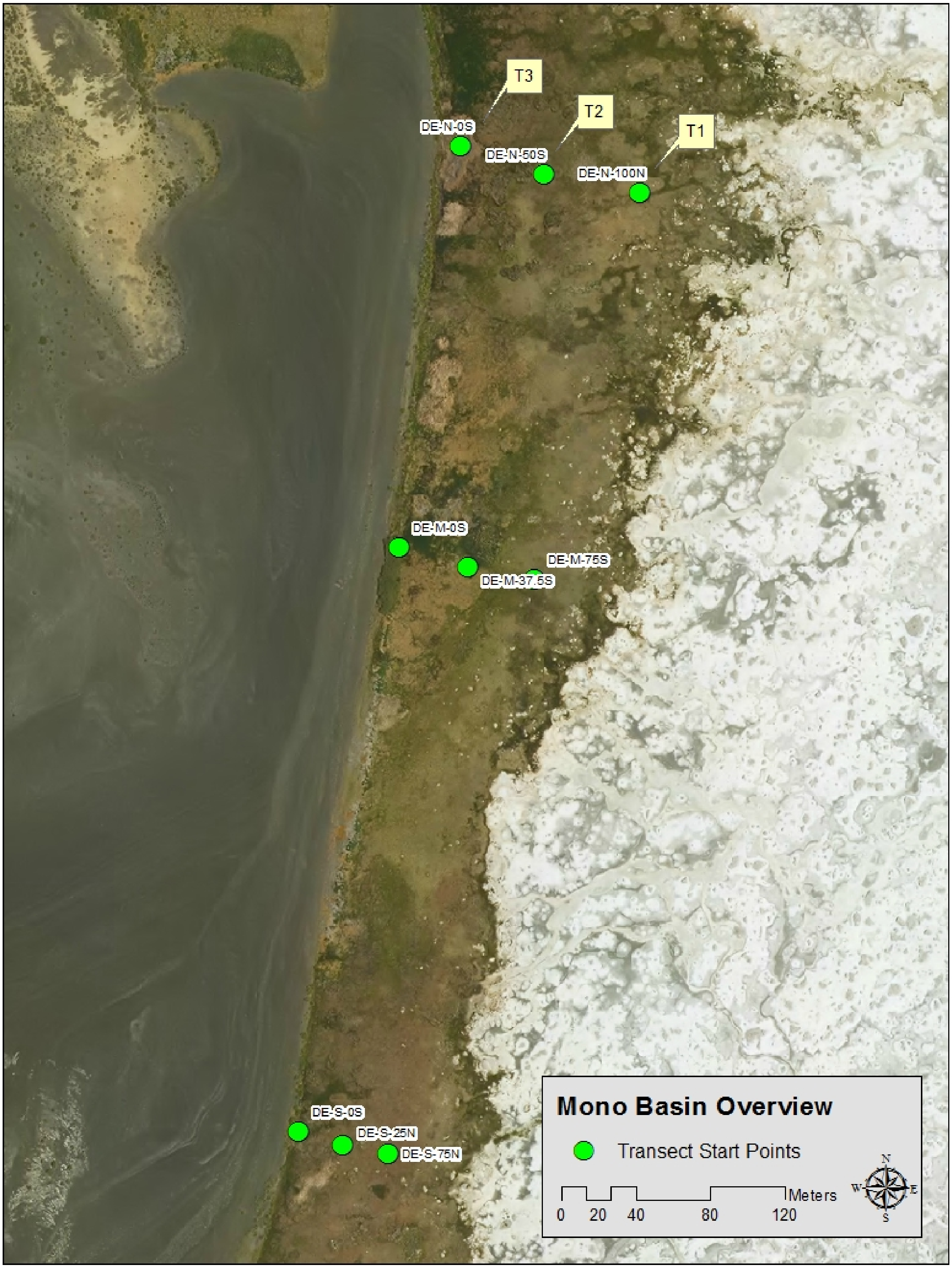


Table 1. Species list and average percent cover for the Dechambeau Embayment wetland vegetation monitoring area. Values are averages of sampling points of approximately equal distance from the lake shore. Transect 1 is closest to the lake while transect 3 is furthest from the lake.

Dechambeau Embayment	Transect 1				Transect 2				Transect 3			
Species	1999	2005	2009	2014	1999	2005	2009	2014	1999	2005	2009	2014
Allenrofea occidentalis	0.7	--	--	--	--	--	--	--	--	--	--	--
Bassia hyssopifolia	0.7	0.7	--	11.3	6.0	--	--	9.3	1.3	--	--	6.0
Brassicaceae	--	--	--	--	--	--	--	--	6.0	--	--	--
Carex rostrata	0.7	--	--	--	--	--	--	--	--	--	--	--
Chenepodaceae	--	--	--	--	--	--	--	--	8.0	--	--	9.3
Chenopodium album	--	--	--	0.0	--	--	1.3	10.0	--	--	7.8	--
Descuriana pinnata	1.3	--	--	--	3.3	--	--	--	18.0	2.7	1.3	--
Distichlis spicata	22.0	10.7	12.4	16.7	14.7	3.3	2.6	0.7	6.0	--	--	--
Epilobium ciliatum ssp. *ciliatum*	--	--	--	0.7	--	0.7	2.6	1.3	--	4.7	3.3	--
Festuca pratensis	--	--	--	2.0	--	--	--	4.0	--	--	--	--
Hordeum jubatum	1.3	6.0	4.6	2.7	44.0	14.7	7.8	23.3	17.3	0.7	--	2.7
Juncus arcticus	1.3	--	--	--	--	3.3	1.3	2.0	0.7	0.7	--	0.7
Lactuca seriola	--	--	--	--	--	--	--	0.7	--	--	3.3	--
Muhlenbergia asperifolia	2.0	4.0	--	--	--	--	--	--	--	--	--	--
Poa pretensis	--	--	5.2	--	--	--	0.6	--	--	--	--	--
Poa secunda	4.0	--	--	--	14.0	5.8	--	--	--	--	--	--
Poa sp.	--	6.7	--	--	--	8.7	--	--	--	--	--	--
Polypogon monospeliensis	--	--	--	--	1.3	--	--	--	4.7	5.3	0.7	--
Rumex salicifolius	--	--	--	--	--	--	0.6	--	--	--	0.7	--
Salix exigua	--	--	--	--	--	--	--	--	0.7	--	8.5	16.0
Salsola tragus	--	--	--	--	--	--	--	--	2.7	--	--	--
Sarcobantus vermiculatus	--	--	--	--	--	--	--	--	0.7	--	--	--
Schoenoplectus acutus	--	--	--	--	--	--	--	--	--	0.7	9.2	4.7
Schoenoplectus americanus	31.2	54.0	50.3	36.7	16.0	61.3	71.4	39.3	27.3	75.3	43.8	35.3
Schoenoplectus maritimus	--	--	13.1	2.0	--	--	--	--	--	--	--	--
Scirpus nevadensis	--	1.3	--	--	--	4.0	0.6	--	--	--	--	--
Triglogin concinna	4.7	--	--	--	--	--	--	--	--	--	--	--
Triglochin maritima	--	6.7	--	--	--	--	--	--	--	--	--	--
Typha latifolia	--	--	--	--	--	--	--	0.7	2.7	9.3	12.4	9.3
Veronica perigrina	--	--	--	--	--	--	--	--	1.3	--	--	--
Bare Ground	--	1.3	0.7	2.7	--	--	--	0.0	--	--	--	0.0
Litter	20.7	7.3	13.7	25.3	--	4.0	11.0	9.3	--	0.7	9.2	16.0
Tufa	--	1.3	--	--	--	--	--	--	--	--	--	--
Water	8.0	2.0	--	--	--	4.0	--	--	1.3	--	--	--

Figure 4. Warm Springs Transect Locations

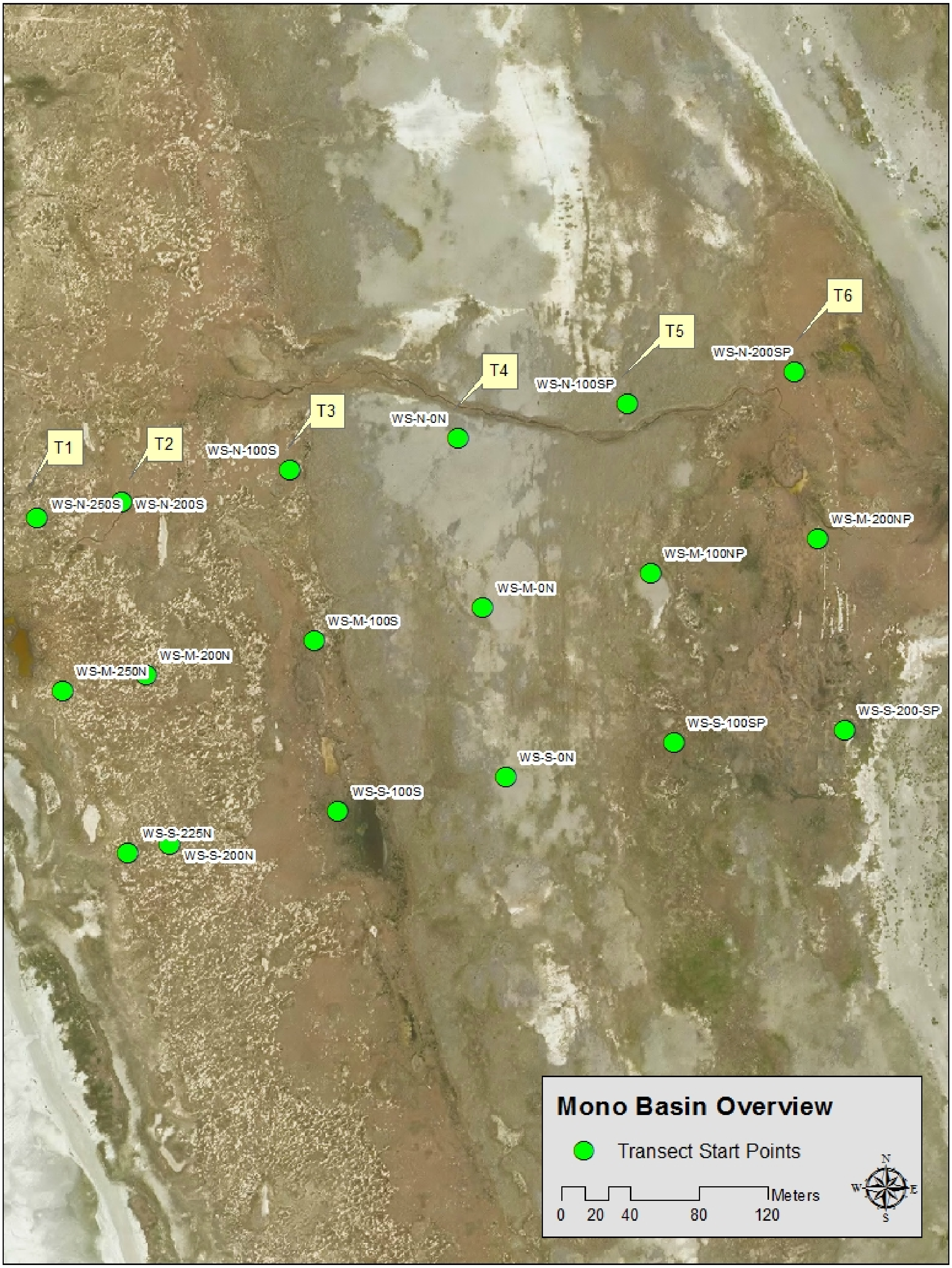


Table 2. Species list and average percent cover for the six sampling transects at the Warm Springs wetland vegetation monitoring area. Values are averages of sampling points. Transect 1 is closest to the lake while transect 6 is furthest from the lake.

Warm Spring	Transect 1				Transect 2				Transect 3				Transect 4				Transect 5				Transect 6			
Species	1999	2005	2009	2014	1999	2005	2009	2014	1999	2005	2009	2014	1999	2005	2009	2014	1999	2005	2009	2014	1999	2005	2009	2014
Artriplex phylostegia	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5.3	--	--	--	--	1.3	--	--	--	--
Atriplex truncata	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1.3	--	--	--	--	--	--
Cleomella plocasperma	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.7	2.0	--	--	--	--
Distichlis spicata	--	--	--	--	--	--	--	--	--	--	--	--	15.3	15.3	3.3	5.3	2.0	1.3	0.7	1.3	--	--	--	--
Eriognum sp.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5.9	3.3	--	--	--	--	--	--	--	--
Festuca pratensis	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4.7	--	--	--	--
Juncus arcticus	--	--	--	--	--	--	--	--	1.3	1.3	2.6	1.3	--	--	--	--	3.3	--	--	2.7	3.3	5.3	7.2	2.7
Muhlenbergia asperifolia	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.7	--	--	--	--	--	--
Nitrophilla occidentalis	--	--	--	--	--	--	--	--	--	--	--	--	--	--	7.2	--	--	2.7	4.6	4.0	--	1.3	--	0.7
Poa pretensis	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3.3	--	--	--	--	--
Psathyrotes annua	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1.3	--	--	--	--	--	--	--	--	--
Schoenoplectus acutus	--	--	--	--	--	--	--	--	16.7	5.3	2.6	5.3	--	--	2.0	--	--	--	--	--	2.7	--	2.6	--
Schoenoplectus americanus	--	--	0.7	--	18.0	16.0	7.9	13.3	5.3	55.3	39.7	53.3	--	--	1.3	2.0	13.3	14.0	9.3	8.0	74.0	78.0	48.0	59.3
Scirpus nevadensis	64.7	72.7	55.0	74.0	58.7	66.0	67.8	48.7	37.3	20.7	7.9	16.7	46.0	49.3	23.7	20.7	62.7	75.3	25.2	29.3	16.0	10.7	12.5	4.7
Triglochin maritima	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1.3	--	--	--	--	--	--
Uk annual forb	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.7	2.7	--	--	--	--	--	--
Uk mustard	10.7	0.7	--	--	3.3	--	--	--	10.7	--	--	--	2.7	--	--	--	2.7	2.6	--	--	2.0	--	--	--
	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Bare Ground	10.7	--	--	--	3.3	--	--	--	6.7	--	2.6	0.7	20.7	16.7	21.1	26.7	1.3	--	3.3	3.3	2.0	--	1.3	--
Litter	10.7	27.3	44.4	26.0	16.0	18.0	24.3	36.7	11.3	12.7	37.1	20.0	15.3	18.7	27.6	41.3	7.3	3.3	52.3	43.3	--	3.3	25.7	30.7
Rock	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1.3	--	--	--	--	--	--	--	0.7	0.7
Tufa	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1.3	--	--
Water	3.3	--	--	--	0.7	--	--	1.3	10.7	4.7	7.3	2.7	--	--	--	0.7	--	--	0.7	--	--	--	2.0	1.3

Figure 5. Sammon Springs Transect Locations.

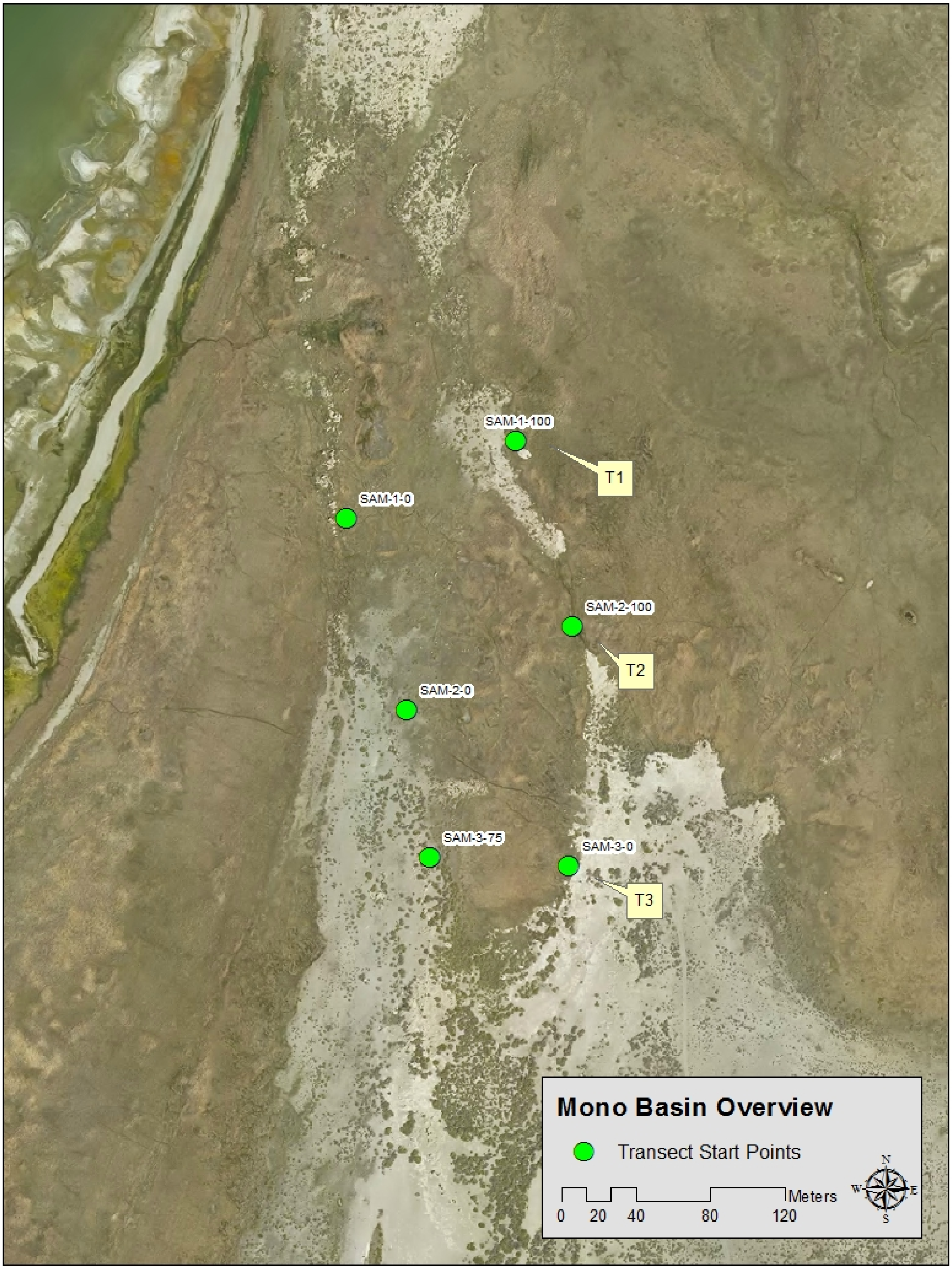


Table 3. Species list and average percent cover for the three sampling transects at the Sammon Springs wetland vegetation monitoring area. Transect 1 is closest to the lake while transect 3 is the furthest from the lake.

Sammon Spring	Transect 1				Transect 2				Transect 3			
Species	1999	2005	2009	2014	1999	2005	2009	2014	1999	2005	2009	2014
AAFF	--	1.3	--	--	--	--	--	--	--	--	--	--
Agrostis sp.	--	--	1.0	--	--	--	--	--	--	--	--	--
Agrostis stolenifera	--	--	--	--	--	--	--	--	--	--	--	--
Brassica sp.	--	1.3	--	5.0	--	--	--	--	--	--	--	--
Casteleja minor	--	--	--	1.0	--	--	--	--	--	--	--	--
Casteleja spp.	--	--	--	--	2.0	--	--	--	--	--	--	--
Carex nebrascensis	--	--	1.0	--	--	--	--	--	--	--	--	--
Carex spp.	--	32.0	3.0	8.0	--	1.0	12.9	5.0	--	2.0	44.7	28.0
Distichlis spicata	10.7	6.7	5.9	--	3.0	--	--	1.0	7.0	4.0	3.9	4.0
Epilobium spp.	2.7	--	--	--	--	--	--	--	--	--	0.0	--
Eleocharis macrostachya	28.0	--	--	--	6.0	--	--	--	5.0	--	0.0	--
Ericameria nauseosa	--	2.7	3.0	5.0	--	1.0	--	2.0	6.0	7.0	1.3	5.3
Hordeum jubatum	--	--	1.0	--	--	--	--	--	2.0	--	--	--
Mimulus glabrata	--	--	--	--	2.0	--	--	--	--	--	--	--
Muhlenbergia asperifolia	--	--	--	4.0	--	--	--	4.0	--	--	--	--
Juncus arcticus	13.3	42.7	9.9	28.0	34.0	49.0	41.6	28.0	17.0	40.0	17.1	18.7
Muhlenbergia asperifolia	--	--	2.0	--	2.0	1.0	2.0	--	2.0	--	--	--
Poa pratensis	--	--	--	--	--	--	--	--	2.0	--	--	--
Schoenoplectus acutus	--	--	2.0	--	27.0	21.0	12.9	14.0	1.0	--	--	--
Schoenoplectus americanus	28.0	9.3	2.0	2.0	8.0	1.0	--	--	10.0	3.0	1.3	4.0
Scirpus nevadensis	5.3	2.7	4.0	5.0	--	3.0	--	--	23.0	17.0	--	--
Solidago spectabilis	--	--	2.0	5.0	3.0	--	--	2.0	4.0	8.0	--	--
Typha latifolia	--	--	1.0	--	7.0	12.0	7.9	6.0	2.0	1.0	--	4.0
Bare Ground	6.3	1.3	12.9	14.0	2.0	1.0	1.0	--	12.0	8.0	5.3	2.7
Litter	6.3	1.3	49.5	23.0	2.0	10.0	21.8	38.0	7.0	5.0	25.0	33.3
Tufa	--	--	--	--	--	--	--	--	--	5.0	--	--
Water	--	--	--	--	2.0	--	--	--	--	--	1.3	--

Tributary Delta Monitoring

Six transects were established within the delta areas of both Rush and Lee Vining Creeks in 1999 (Figures 6 and 7). A seventh transect was added at the mouth of Rush Creek during the 2009 sampling season. The first transect is located near the mouth of each delta. Subsequent transects were established upstream of the deltas at approximately 100-meter intervals. Vegetation monitoring was conducted using the line-point intercept method to determine species composition and cover for each site. These data are presented in Tables 4 and 5. Horizontal coordinates of each sampling transect were determined with GPS. GPS readings were also taken at approximately 10-meter intervals along each sampling transect. With all sampling, caution was taken to not disturb existing monitoring areas. Transects varied in length, depending on the width of the floodplain, beginning from the top of the bank descending into the flood plain across the creek channel and up the opposite bank. The sampling interval was 20-25 steps in 1999, 2009, 2014 and every other step in 2005.

Figure 6. Lee Vining Creek Transect Locations.

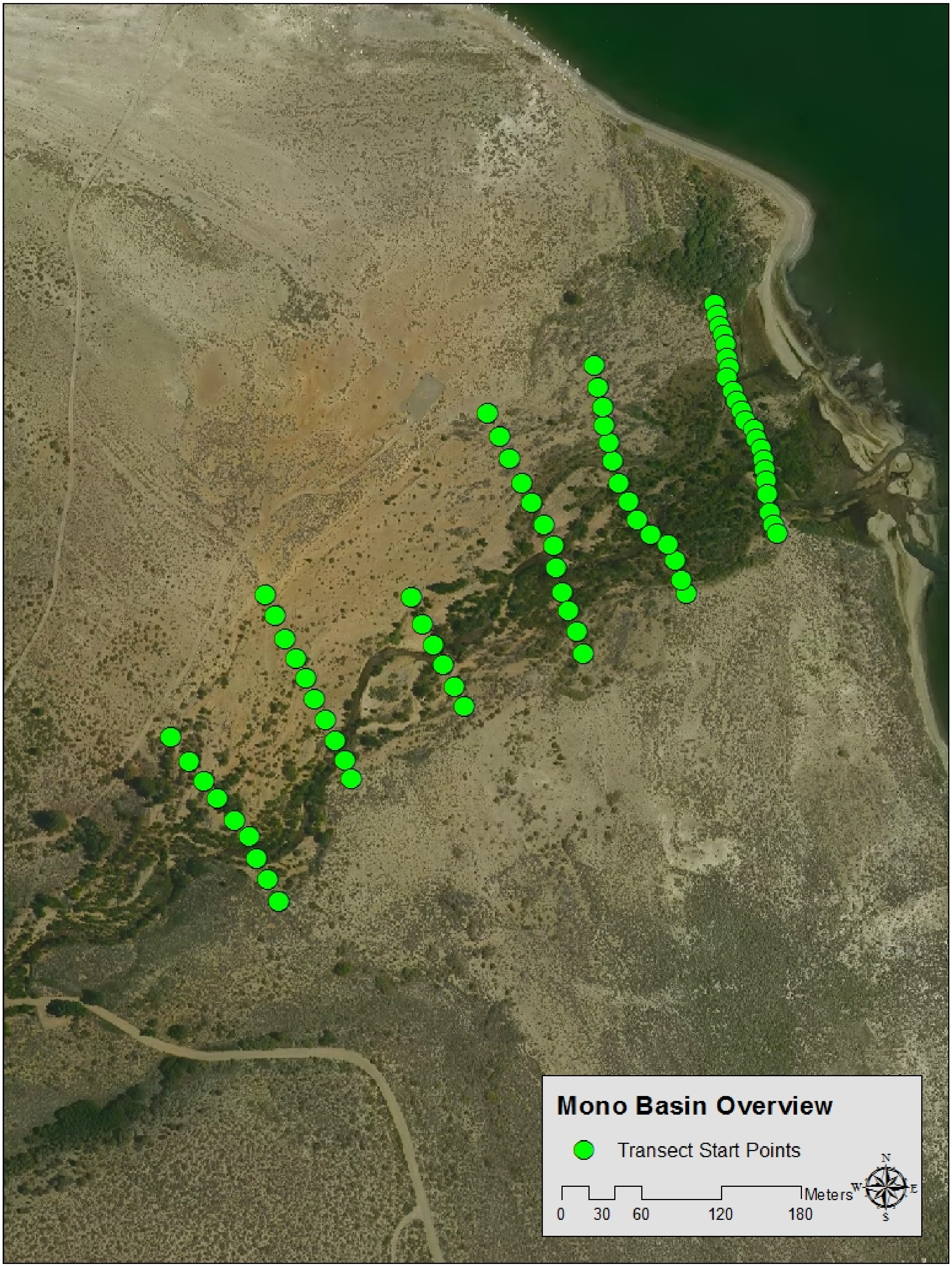


Table 4. Species list and average percent cover for each of the transects at the Lee Vining Delta vegetation monitoring area. Transect 1 is closest to the lake while transect 6 is furthest from the lake.

Lee Vining Creek	Transect 1				Transect 2				Transect 3				Transect 4				Transect 5				Transect 6			
Species	1999	2005	2009	2014	1999	2005	2009	2014	1999	2005	2009	2014	1999	2005	2009	2014	1999	2005	2009	2014	1999	2005	2009	2014
Achillea millefolium	--	0.8	--	8.3	--	--	--	--	--	2.1	6.7	--	--	0.7	--	14.3	--	--	--	--	--	--	--	--
Agrostis scabra	--	--	--	--	--	--	--	--	--	--	6.7	--	--	--	18.2	--	--	--	--	--	--	--	--	--
Agrostis stolonifera	4.4	--	--	--	--	0.4	--	9.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Ambrosia acanthicarpa	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	7.7	--	--	--	--
Annual Forb	--	0.4	--	--	--	0.3	--	--	--	--	--	--	--	--	--	--	--	0.4	--	--	--	0.4	--	--
Arnica longifolia	--	0.8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Artemesia ludoviciana	--	0.8	3.1	--	2.9	--	6.5	--	3.9	2.8	--	13.3	3.6	0.7	9.1	42.9	1.7	0.4	8.3	7.7	1.9	1.7	5.3	--
Artemesia tridentata	4.3	0.4	--	8.3	1.0	--	--	--	--	--	--	13.3	0.7	0.7	--	--	2.3	1.8	--	7.7	0.6	2.1	10.5	15.4
Calamagrostis niglecta	--	--	--	--	--	1.0	--	--	--	2.4	--	--	--	2.2	--	--	--	--	--	--	--	--	--	--
Carex sp.	--	1.9	--	16.7	--	5.6	--	--	--	2.4	--	--	--	--	--	--	--	--	--	--	--	0.8	--	--
Carex utriculata	--	--	15.6	--	--	--	16.1	--	--	--	3.3	--	--	--	--	--	--	--	8.3	--	--	--	--	--
Chrysothamnus nauseosus	--	1.5	--	--	--	0.3	--	--	--	--	--	--	--	--	--	--	0.6	0.4	--	--	--	0.8	--	--
Casteleja sp.	--	--	3.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cirsium vulgare	--	0.4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cornus sericea	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	7.7	--	--	--	--
Cyperus sp.	--	--	6.3	--	1.0	--	3.2	9.1	1.0	--	3.3	--	--	--	--	--	--	--	--	--	--	--	--	--
Distichlis spicata	--	--	--	--	1.0	--	--	--	--	--	--	--	--	--	--	--	4.5	--	--	--	1.8	--	--	--
Eleocharis sp.	--	0.4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Epilobium ciliatum var. *ciliatum*	--	0.8	--	--	--	--	--	--	--	1.7	--	13.3	--	--	--	--	--	--	--	--	--	--	--	--
Ericameria nauseosa	--	1.5	--	--	--	0.4	--	9.1	--	--	3.3	--	--	--	--	14.3	--	0.4	--	--	--	0.8	--	--
Erigeron sp.	--	--	3.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Juncus arcticus	--	4.6	--	8.3	--	1.4	--	9.1	--	1.4	--	--	--	--	--	--	--	--	--	--	0.6	2.5	--	--
Juncus nevadensis	--	3.5	6.3	--	6.7	4.9	12.9	9.1	--	4.5	6.7	--	2.9	0.7	--	--	--	--	--	--	--	--	--	--
Juncus orthophyllus	--	--	--	--	--	0.7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Juncus sp.	--	--	3.1	--	--	--	3.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Lepidium virginicum	--	--	--	--	--	--	--	--	--	--	--	6.7	--	--	--	--	--	--	--	--	--	--	--	--
Lupine sp.	4.3	3.5	9.4	--	3.8	2.8	9.7	18.2	5.8	6.6	6.7	6.7	2.2	--	9.1	--	1.1	0.9	--	--	3.7	10.1	21.1	--
Melalotis alba	8.7	--	--	--	4.8	--	--	--	1.0	--	--	--	--	--	--	--	--	--	--	--	1.8	--	--	--
Medicago lupulina	--	4.2	--	--	--	1.8	--	--	--	1.0	--	--	0.7	--	--	--	--	--	--	--	--	--	--	--
Melolotus officinalis	--	--	6.3	--	--	--	3.2	--	--	--	3.3	--	--	--	--	--	--	--	--	--	--	--	--	--
Mimulus floribundus	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.4	--	--
Mimulus guttatus	--	--	--	--	--	--	--	--	--	--	3.3	--	--	--	--	--	--	--	--	--	--	--	--	--
Muhlenbergia spp.	4.3	3.9	9.4	--	--	1.1	9.7	--	--	0.3	3.3	--	2.2	--	9.1	--	--	0.4	--	--	2.5	--	--	--
Oenothera elata	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	7.7

Lee Vining Creek	Transect 1				Transect 2				Transect 3				Transect 4				Transect 5				Transect 6			
Species	1999	2005	2009	2014	1999	2005	2009	2014	1999	2005	2009	2014	1999	2005	2009	2014	1999	2005	2009	2014	1999	2005	2009	2014
Oenothera sp.	--	0.4	3.1	--	--	--	3.2	--	--	--	3.3	--	--	--	--	--	--	--	--	--	--	--	--	--
Penstemon sp.	--	--	--	--	--	--	--	--	--	1.4	--	--	--	5.1	--	--	--	2.2	--	--	--	0.4	--	--
Phlox sp.	--	--	--	--	--	--	--	--	--	0.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pinus contorta	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	8.3	7.7	--	--	--	--
Pinus jeffreyi	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	16.7	--	--	--	--	--
Poa pratensis	--	--	--	--	--	6.3	--	--	1.9	0.3	--	--	1.4	--	--	--	0.6	--	--	--	0.6	0.4	--	--
Poa secunda	--	--	--	--	--	--	--	--	--	--	--	--	--	0.7	--	--	1.7	--	--	--	--	--	--	--
Poa sp.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	9.1	--	--	--	8.3	--	--	--	--	--
Populus balsamifera	--	0.4	--	--	--	0.4	--	--	--	0.7	13.3	--	--	4.4	--	--	--	2.2	16.7	15.4	--	2.1	21.1	30.8
Populus freemontii	--	0.4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Populus trichocarpa	--	0.8	--	--	1.0	0.3	--	--	--	0.7	--	--	--	4.3	--	--	4.5	2.2	--	--	12.3	2.1	--	--
Purshia tridentata	--	--	--	--	--	--	--	--	--	0.3	--	6.7	--	0.7	9.1	14.3	2.3	2.7	16.7	23.1	--	4.6	15.8	--
Rosa woodsii	--	0.4	3.1	--	--	0.4	--	9.1	1.0	--	--	6.7	--	--	9.1	--	4.0	--	--	7.7	3.1	--	5.3	23.1
Rumex crispus	--	--	--	--	--	--	--	9.1	1.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Salix sp.	4.4	--	--	--	--	--	--	--	--	2.4	--	--	--	2.9	--	--	--	--	--	--	--	--	--	--
Salix exigua	13.0	9.3	12.5	33.3	45.2	9.5	19.4	18.2	23.3	5.9	20.0	13.3	5.0	0.7	18.2	14.3	2.3	--	8.3	7.7	2.5	--	5.3	--
Salix exigua (dead)	17.4	0.4	--	--	--	0.3	--	--	2.0	0.7	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Salix lutea	--	3.5	3.1	8.3	4.8	4.9	3.2	--	6.8	1.4	--	13.3	--	0.7	--	--	--	--	--	7.7	4.9	0.4	--	23.1
Saponaria officinalis	--	0.8	--	--	--	2.8	6.5	--	--	1.0	6.7	--	--	--	9.1	--	--	--	8.3	--	--	--	15.8	--
Schoenoplectus americanus	--	3.5	3.1	8.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Solidago spectabilis	--	9.3	6.3	8.3	1.9	5.6	3.2	--	--	1.7	3.3	--	--	--	--	--	--	--	--	--	--	--	--	--
Symphyotrichum spathulatum	--	--	--	--	--	--	--	--	--	0.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Trifolium longipes	--	0.4	--	--	--	0.4	--	--	--	0.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Trifolium sp.	--	--	--	--	--	--	--	--	--	--	3.3	--	--	--	--	--	--	--	--	--	--	--	--	--
Typha latifolia	--	0.8	3.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Verbascum thapsus	--	--	--	--	--	--	--	--	--	--	3.3	6.7	--	--	--	--	--	--	--	--	--	0.4	--	--
Valeriana californica	--	--	--	--	--	--	--	--	2.9	--	--	--	2.9	--	--	--	1.1	--	--	--	--	--	--	--
Bare Ground	17.4	2.7	--	--	9.6	4.9	--	--	29.1	3.8	--	--	51.8	5.1	--	--	57.6	5.8	--	--	42.9	8.4	--	--
Litter	8.7	9.3	--	--	9.6	12.0	--	--	12.6	19.4	--	--	5.0	10.3	--	--	8.5	7.1	--	--	14.7	15.6	--	--
Moss	--	--	--	--	--	0.4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Rock	--	9.3	--	--	--	21.8	--	--	--	26.4	--	--	--	57.4	--	--	--	66.7	--	--	--	38.8	--	--
Water	13.0	9.3	--	--	6.7	11.6	--	--	6.8	11.1	--	--	21.6	8.8	--	--	7.3	9.3	--	--	6.1	10.1	--	--

Figure 7. Rush Creek Sampling Locations.

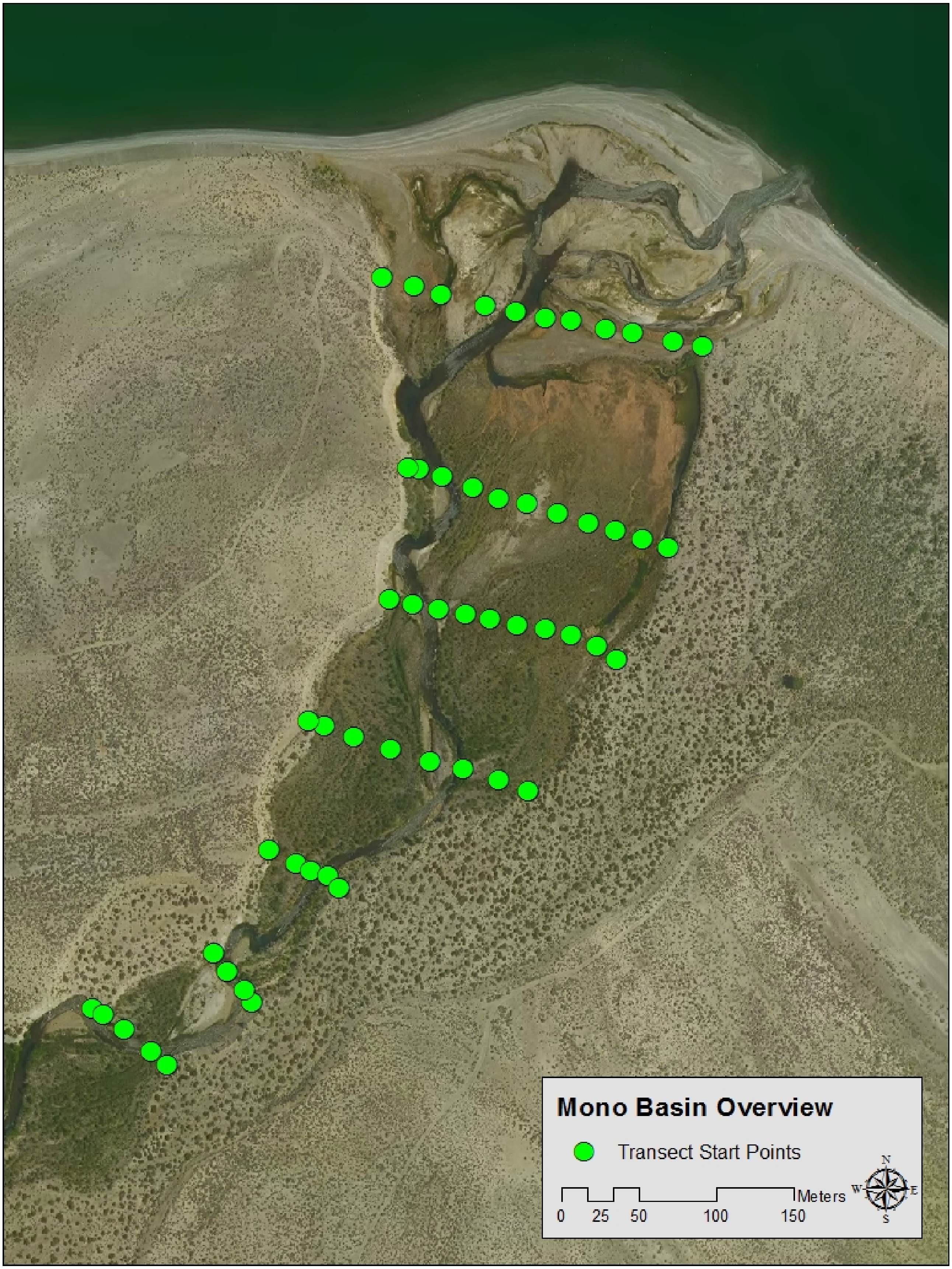


Table 5. Species list and average percent cover for each of the transects at the Rush Creek Delta vegetation monitoring area. Transect 7 is closest to the lake followed by Transects 1 through 6.

Rush Creek	Transect 1				Transect 2				Transect 3				Transect 4				Transect 5				Transect 6				Transect 7	
Species	1999	2005	2009	2014	1999	2005	2009	2014	1999	2005	2009	2014	1999	2005	2009	2014	1999	2005	2009	2014	1999	2005	2009	2014	2009	2014
Annual Forb	0.5	1.1	--	--	--	1.1	--	--	--	2.1	--	--	--	--	--	--	--	3.0	--	--	--	--	--	--	--	--
Achillea millefolium	--	--	--	--	--	--	--	--	--	0.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Achnatherum hymenoides	--	--	--	--	--	--	--	**9.1**	--	--	8.3	**9.1**	--	--	--	--	--	--	--	--	--	--	--	**20.0**	--	--
Arnica longifolia	--	--	--	--	--	--	--	--	--	0.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Artemesia ludoviciana	--	0.4	--	--	--	--	--	--	--	--	8.3	**18.2**	--	--	--	--	--	--	--	--	1.4	2.4	--	--	--	--
Artemesia tridentata	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	14.3	--	--	--
Aster sp.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	7.1	--
Astragalus canadensis	--	--	--	--	--	--	--	--	--	0.5	--	--	--	--	--	--	--	3.2	--	--	--	--	--	--	--	--
Berula erecta	--	--	--	--	--	--	--	--	--	--	8.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Carex aquatilis	--	--	--	--	1.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Carex douglasii	--	--	--	--	--	--	--	--	--	1.9	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Carex nebrascensis	0.5	1.9	--	--	--	0.9	--	**18.2**	--	4.2	--	--	--	--	--	--	3.9	--	--	--	2.4	3.6	--	--	--	--
Carex praegracilis	0.5	--	--	--	--	--	--	--	0.6	--	--	--	--	--	--	--	5.9	--	--	--	--	--	--	--	--	--
Carex sp.	--	--	--	--	--	--	--	--	--	6.0	--	--	--	5.1	--	--	--	--	--	--	--	--	--	--	--	--
Carex utriculata	--	--	--	--	--	--	7.7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Casteleja sp.	--	--	7.7	--	--	--	--	--	--	0.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Chrysothamnus nauseosus	--	--	--	--	--	--	--	--	1.1	--	--	--	1.6	--	--	--	2.0	--	--	--	--	--	--	--	--	--
Deschampsia cespitosa	2.0	--	--	--	--	0.4	7.7	--	--	--	8.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Distichlis spicata	--	0.4	--	--	--	--	--	--	--	--	--	--	--	2.5	--	--	--	--	--	--	2.4	1.2	--	--	7.1	**18.2**
Eleocharis macrostachya	--	--	--	--	--	--	--	**9.1**	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	**--**
Eleocharis sp.	--	1.9	--	--	--	--	--	--	--	1.4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Epilobium ciliatum ssp. *ciliatum*	--	0.4	--	--	--	--	--	--	--	0.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Epipactis gigantea	--	--	--	--	--	--	--	**9.1**	--	--	8.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Equisetum arvense	--	0.4	7.7	--	--	--	--	--	--	--	--	--	--	--	--	**20.0**	--	1.6	50.0	**20.0**	--	1.2	42.9	**60.0**	--	--
Ericameria nauseosa	--	--	7.7	--	--	--	--	--	--	--	--	--	--	2.5	16.7	--	--	3.2	--	--	--	1.2	--	--	--	**9.1**
Eriognum sp.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Iris sp.	--	--	--	--	--	--	7.7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Juncus arcticus	11.0	20.2	15.4	**66.7**	23.8	29.6	7.7	**18.2**	14.7	18.6	25.0	**18.2**	12.7	16.5	16.7	**20.0**	13.7	15.9	--	--	8.4	2.4	--	--	--	--
Juncus bufonis	1.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Juncus longistylus	3.5	--	--	--	3.3	--	--	--	2.8	--	--	--	1.6	--	--	--	--	--	--	--	--	--	--	--	--	--
Juncus nevadensis	--	9.0	--	--	--	11.7	--	--	--	14.9	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Lupinus sp.	--	8.6	--	--	0.6	--	--	--	1.1	0.5	16.7	**27.3**	17.5	11.4	--	--	--	--	--	--	--	--	--	--	--	--

Rush Creek	Transect 1				Transect 2				Transect 3				Transect 4				Transect 5				Transect 6				Transect 7	
Species	1999	2005	2009	2014	1999	2005	2009	2014	1999	2005	2009	2014	1999	2005	2009	2014	1999	2005	2009	2014	1999	2005	2009	2014	2009	2014
Mentzelia laevicaulis	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	7.1	--
Mimulus guttatus	--	1.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Muhlenbergia asperifolia	--	2.2	7.7	**22.2**	--	1.3	15.4	--	0.6	3.7	--	--	--	6.3	--	--	--	11.1	--	--	--	--	--	--	7.1	--
Muhlenbergia spp.	3.0	--	--	--	1.1	--	--	--	1.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Poa pretensis	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	25.0	--	--	--	--	--	--	--
Poa secunda	--	--	--	--	--	--	--	--	2.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Potentilla biennis	0.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Purshia tridentata	--	--	--	--	--	2.2	7.7	**9.1**	0.6	2.8	8.3	**9.1**	--	2.5	16.7	**40.0**	--	--	--	--	--	--	14.3	--	--	--
Rosa woodsii	--	--	--	--	--	--	--	--	--	--	--	--	--	1.3	16.7	--	--	3.2	--	**20.0**	--	--	--	--	--	--
Rumex crispus	--	--	--	--	--	0.4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Salix exigua	32.5	7.9	23.1	--	27.8	14.3	15.4	**18.2**	39.5	9.3	8.3	--	39.7	1.3	--	**20.0**	19.6	1.6	--	--	28.9	3.6	--	--	7.1	**9.1**
Salix exigua (dead)	6.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Salix lutea	--	14.6	15.4	--	2.8	9.0	15.4	**9.1**	6.2	17.2	--	--	--	8.9	--	--	3.9	1.6	--	**20.0**	--	3.6	14.3	**20.0**	--	**9.1**
Salsola tragus	--	--	--	--	--	--	--	**--**	--	--	--	--	--	--	--	--	--	--	--	**20.0**	--	--	--	**--**	--	**--**
Schoenoplectus americanus	--	4.9	--	--	--	0.4	7.7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	21.4	**45.5**
Scirpus microcarpus	--	--	7.7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Scirpus nevadensis	--	1.1	--	--	--	--	--	--	--	0.9	--	--	--	--	--	--	--	--	--	--	--	--	--	--	21.4	**9.1**
Senecio hydrophilus	--	--	--	--	--	0.4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sheperdia argentea	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1.2	--	--	--	--
Solidago spectabilis	0.5	--	7.7	--	--	--	7.7	--	--	0.9	--	**9.1**	--	5.1	--	--	3.9	--	--	--	--	--	--	--	--	--
Tamarix rammosisima	0.5	--	--	--	0.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Triglochin maritimus	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Unk Boraginaceae	--	--	--	--	--	0.4	--	--	--	--	--	--	--	--	16.7	--	--	--	25.0	--	--	--	--	--	--	--
Verbascum thapsus	--	--	--	--	--	--	--	--	--	--	--	--	--	1.3	16.7	--	--	--	--	--	--	--	--	--	--	--
Veronica anagallis-aquatica	--	0.7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Bare ground	17.0	4.1	--	--	13.8	5.4	--	--	16.9	0.9	--	--	9.5	3.8	--	--	17.6	3.2	--	--	21.7	10.7	--	--	--	--
Litter	3.0	7.5	--	--	2.7	5.4	--	--	3.4	4.2	--	--	--	7.6	--	--	--	12.7	--	--	3.6	4.8	--	--	--	--
Rock	--	7.1	--	--	--	8.1	--	--	--	4.7	--	--	--	5.1	--	--	--	15.9	--	--	--	14.3	--	--	--	--
Water	17.5	5.6	--	**11.1**	22.2	9.9	--	--	8.5	5.6	--	**9.1**	15.9	19.0	--	--	29.4	27.0	--	**20.0**	31.3	50.0	14.3	--	21.4	--

Analysis

For each monitoring site, average cover by species was calculated for all four sampling years (1999, 2005, 2009, and 2014) by combining all the sampling points of approximately equal distance from the lake shore. These values were then used to calculate indices of community similarity to compare how similar the communities were between the sampling periods. Six sets of similarity indices were calculated between two sampling years (1999 and 2014, 1999 and 2009, 1999 and 2005, 2005 and 2014, 2005 and 2009, 2009 and 2014). Two different indices were selected, the Proportional Similarity Index (PS) (Brower et al. 1990) and Morisita's Index (MI) (Brower et al. 1990). The Proportional Similarity Index is based on differences of percent covers of the same species in two communities (in this study two sampling years) the higher the index value for the two communities of interest, the greater the similarity is between species cover values. Morisita's index is based on the probability that two randomly selected individuals from a community will be the same species. Thus, the index value will be higher when the same species are found dominant or common in the two communities. For both indices, values can range from 0.0 to 1.0, with an index of 0.0 indicating the species composition between two sampling periods are completely different and a index of 1.0 indicating they are identical.

Results

Comparisons among sampling sites show that changes between sampling years have occurred at some sites while very little change has occurred at others. The similarity indices show that there have been minimal changes in the plant community at Warm Springs between all sampling years as PI values are greater than 0.82 and MI values are greater than 0.92 even comparing between 1999 and 2014 indicating that plant communities have changed very little since 1999. The dominant species there are *Schoenoplectus americanus* and *Scirpus nevadensis*.

Dechambeau Embayment percent cover of species has been changing over time as PI values range from 0.48 to 0.78 but species composition has remained fairly static as MI values range from 0.66 to 0.98. There has been a decrease in percent cover of *Distichlis spicata* and *Hordeum jubatum*, and an increase of *Schoenoplectus americanus* across all transects, suggesting that the community composition is beginning to move to a later seral state.

Larger changes were observed at Sammon Springs as both indices are lower than the previous two sites between the sampling years of 1999 and 2014 (PI = 0.63 and MI = 0.67). This indicates that not only has percent cover changed over time, so has the species composition. *Schoenoplectus americanus* and *Scripus nevadensis* are decreasing in percent cover while *Juncus arcticus* and litter are increasing in percent cover.

Analyses of Rush and Lee Vining Creeks show that the community composition has changed as MI values range from 0.41 to 0.86 and PI values range from 0.46 to 0.79. Notable changes observed at Rush Creek are an increase in the percent cover of *Salix lutea*, a decrease in percent cover of *Salix exigua*, and colonization of *Solidago spectablis*. Also, along transect 7 there is an abundance of *Schenoplectus americanus,* a late seral species that is indicative of a wetland environment. At Lee Vining Creek, notable changes are an increase in *Artemesia ludoviciana*, *A. tridentata*, *Purshia tridentata*, *Rosa woodsii* and *Salix lutea*. *S. exigua* has remained stable across all years.

Results for all sites are displayed in table 6.

Table 6. Indices of community similarity for the Mono Basin Lake fringing wetlands and tributary deltas.

Site	Index*	1999-2014	1999-2009	1999-2005	2005-2014	2005-2009	2009-2014
Dechambeau Embayment	PI	0.62	0.48	0.51	0.64	0.78	0.74
	MI	0.82	0.74	0.66	0.85	0.98	0.90
Warm Spring	PI	0.84	0.85	0.90	0.87	0.82	0.95
	MI	0.93	0.93	0.98	0.94	0.92	0.99
Sammon Spring	PI	0.63	0.64	0.63	0.80	0.75	0.88
	MI	0.67	0.58	0.72	0.87	0.82	0.97
Rush Creek	PI	0.51	0.46	0.68	0.58	0.67	0.69
	MI	0.48	0.44	0.56	0.59	0.70	0.86
Lee Vining Creek	PI	0.59	0.57	0.79	0.55	0.54	0.52
	MI	0.63	0.61	0.57	0.41	0.44	0.71

** PI indicates Proportional Similarity Index. MI indicates Morisita's Index.*

Discussion

Succession is a natural process describing the sequential changes in plant and animal communities. Succession is affected by both exogenous processes, such as a change in water levels and endogenous processes such as competition and facilitation in which each new community creates an environment favorable for colonization by other plant and animal species. During succession, the diversity of plant species generally decrease, the height and the size of the dominant plant species generally increases and the size of the plant seeds generally increases. Wetlands are dynamic with species and community composition reflecting changing water levels. Part of the diversity of the wetlands is dependent on dynamic change. During the course of this study, the elevation of Mono Lake has fluctuated giving no particular advantage to a specialist species, unless adapted to a fluctuating lake level. During years of a receding lake level, 1999-2004 and 2006-2010 and 2012-2015, it is plausible that the hydrologic effect on the wetland and tributary delta areas will be less than during years that the lake level is rising and that the salinity should decrease. With a declining lake level and subsequently lesser hydrologic effect, this might be beneficial for the expansion of freshwater spring and wetland systems. On the other hand, with an increased lake level increasing the hydrologic affect, this should favor species that are adapted to a more saline environment and restrict the expansion of springs and wetland environments. Because the elevation of Mono Lake has been fluctuating over the course of this study, and similarity indices indicate changes among some but not all of the wetland and tributary delta study areas, it is hard to address the effect that the lake is having on these communities.

At Dechambeau Embayment, the community composition is heading towards a more stable climax community. This can be observed with the change in percent cover of both *Hordeum jubatum* and *Schoenoplectus americanus. Hordeum jubatum,* an early seral species, being replaced by *Schoenoplectus americanus*, a later seral species. With a decrease in the lake level, the lake is having less of an effect on the site and allowing for the development of a marsh habitat type. This can be observed on transect 2 and 3, which are farthest from the lake shore and closest to the spring head. Both *Schoenoplectus acutus* and *Typha latifolia*, indicators of a marsh habitat, are increasing in percent cover. *Hordeum jubatum* is decreasing in percent cover across all transects and *Distichlis spicata* has decreased across all transects, suggesting that there is a possible decrease in the salinity (lake effect) on this site.

There has been little in the way of disturbance at Warm Springs since the initial sampling year. The site is dominated by few species, which are later seral species such as *Schoenoplectus americanus* and *Scirpus nevadensis*. Early seral species, such as *Hordeum jubatum*, have not been a component of the site since the initial sampling year. The community composition is stable, and without disturbance will likely persist as a climax community.

The changes observed at Sammon Springs suggest that the community composition is changing. Along with a fluctuating lake level, State Parks commenced a prescribed burning program prior to the initial sampling conducted in 1999. The site was burned for two consecutive years. When the transects were established in 1999, the site was composed of an ash layer and burned stobs of *Schoenoplectus americanus* and *Typha latifolia*. Therefore, some vegetation changes are a result of the sampling area recovering from those burns. In 2014, with a decreased lake level, the transects can be broken into zones following a gradient of fresh to saline conditions across the site. Transect 1 is the lake zone, Transect 2 is the intermediate zone, and Transect 3 is the spring zone. Along transect 3 there is greater spring influence increasing the percent cover of *Carex* spp. Also, litter is increasing. Transect 2 is moving toward a stable community composition of both *Juncus arcticus* and *Schoenoplectus acutus* suggesting that it is the driest area of the site. Transect 1 is closest to the lake and is exhibiting an overall decrease in species composition and an increase in percent cover of litter. It is plausible that the amount of decadence along Transect 1 is consuming available space for the establishment of *Schoenoplectus acutus* and *Schoenoplectus americanus*. As litter increases, it is expected that recruitment and overall percent cover of the site will continue on a downward trend.

The results observed at both Rush and Lee Vining Creeks can be attributed to multiple factors. Some of the changes are most likely attributable to changing delta areas between sampling periods. The changes are most evident in the Rush Creek delta and displayed on (Figures 8, 9, 10, 11). In 2000 there is a lack of a delta area. Sediment deposition is noticeable, however the lake elevation was approximately 6,384 ft above msl which covered the deposits and held back the creek channel. The creek channel is to the far left of the flood plain against the upland vegetation. *Salix exigua* is a large component of the site. In 2005, 2009, and 2014, with a decreased lake level, the creek channel is beginning to braid and delta deposits are beginning to be exposed. There is a decrease in the percent cover of *Salix exigua* and an increase in *Juncus arcticus* indicating the presence of a wetter, fresh water environment. Also, *Salix lutea* is beginning to colonize the site suggesting that delta deposits are increasing the available space for recruitment and establishment of the species. In 2014 the delta area is considerably different from that of 2000 (Figure 21). There is a highly developed delta with littoral bar formation at the mouth. The lake level has receded to 6379 feet above msl which has promoted movement of the creek channel to the center of the flood plain. The creek channel has become less braided and incised within the newly exposed delta deposits. Also, with the decreased lake level, the flood plain has expanded in width increasing the area of exposed flood plain with colonization of *Solidago spectablis* and decrease in the percent cover of *Salix exigua*.

The observed changes in the vegetation composition may also be attributed to the fact that permanent transect markers were not established. Therefore, when sampling was conducted, a GPS unit was utilized to locate the transects and follow the sampling route. Utilizing this same method in 2005, 2009, and 2014 likely resulted in some "straying" from the original course which could have resulted in some of the differences. Also, there is unevenness in the sampling interval across years. The sampling interval for 1999, 2009, 2014 is consistent with a point read every 20-25 steps. In 2005, the sampling interval was every other step. This has lead to an increase in species richness and a more even distribution of species across transects compared to 1999, 2009, and 2014. For example, in 2014, Rush Creek Transect 6 had a 60% cover of *Equisetum arvense* due to the limited number of sampling points along the transect (Table 5). The percent cover of *E. arvense* does not accurately represent the composition of those particular transects. Because of the inconsistencies with the sampling methodology it is difficult to infer the PI and MI values for plant communities’ changes over time.

Figure 8. 2000 Imagery of Rush Creek delta.

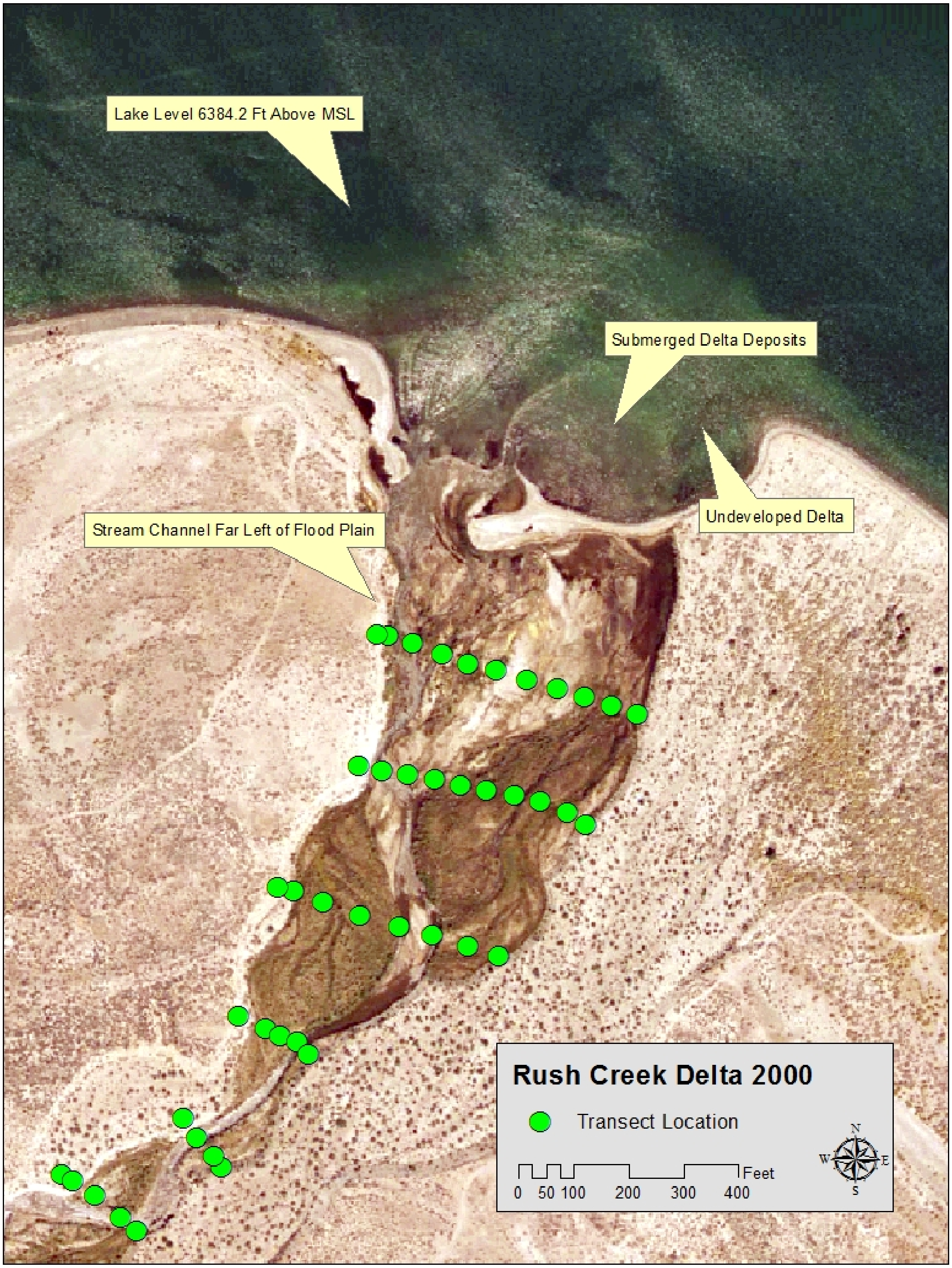


Figure 9. 2005 imagery of Rush Creek delta.

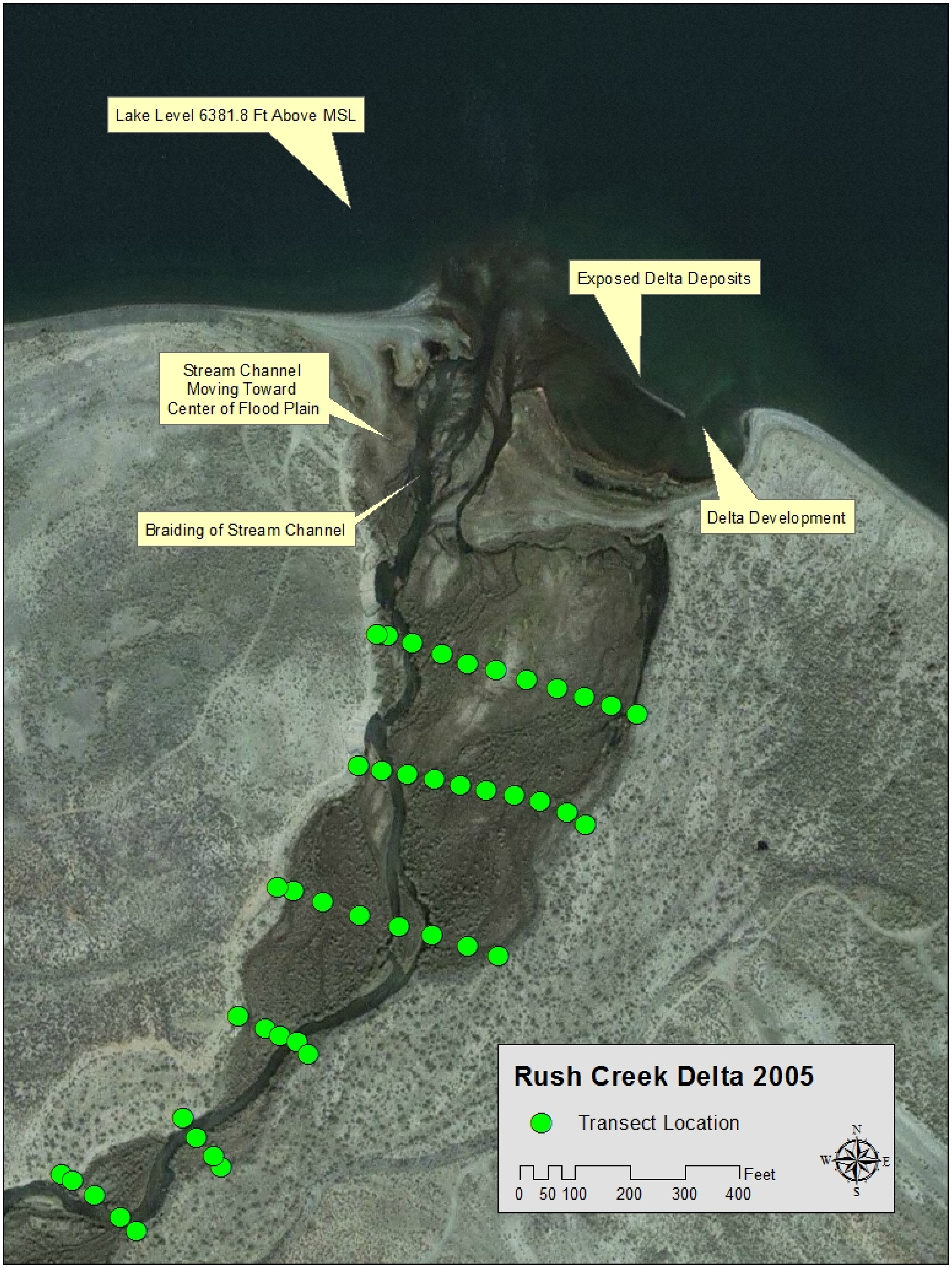


Figure 10. 2009 imagery of Rush Creek delta.

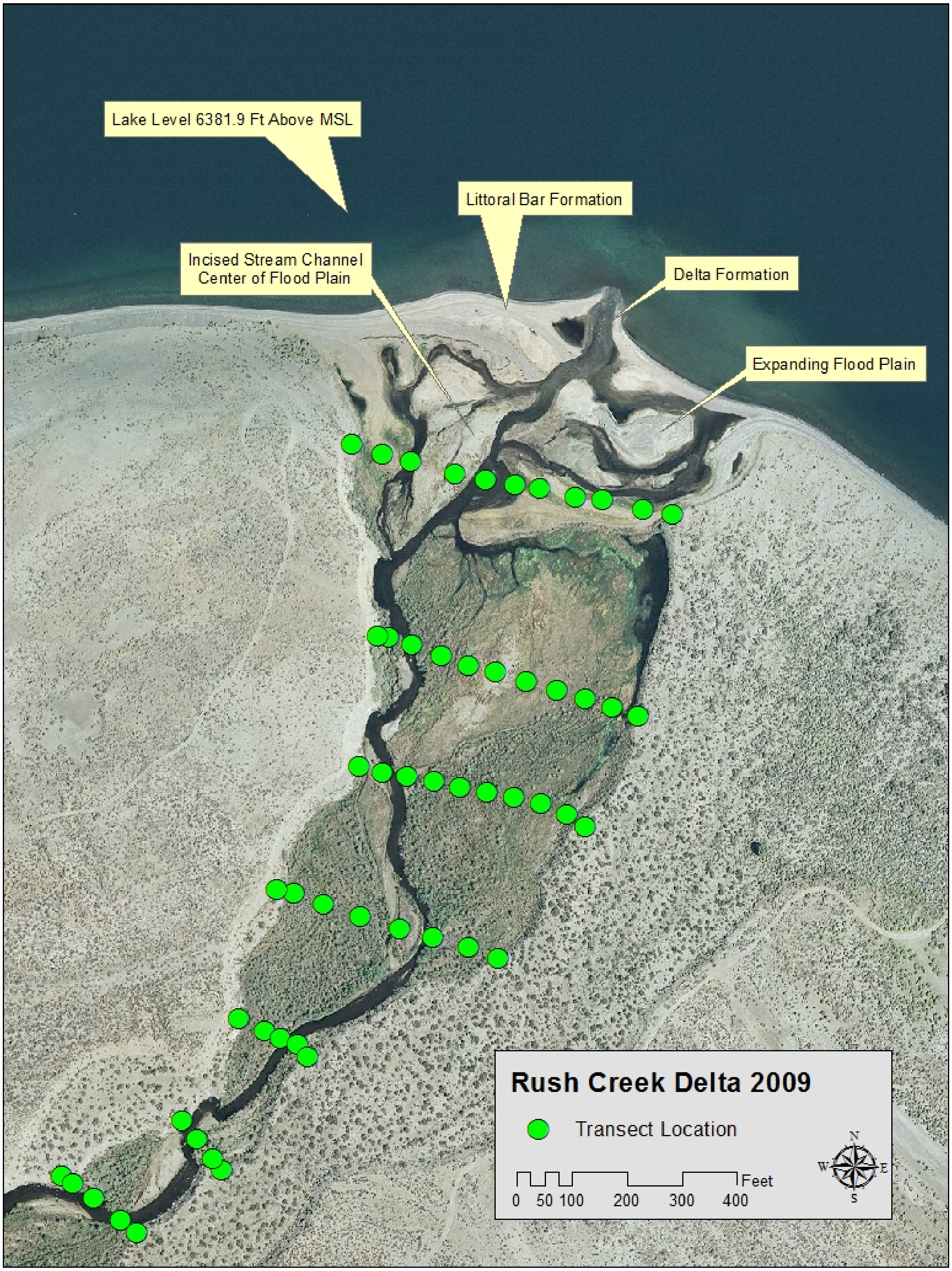
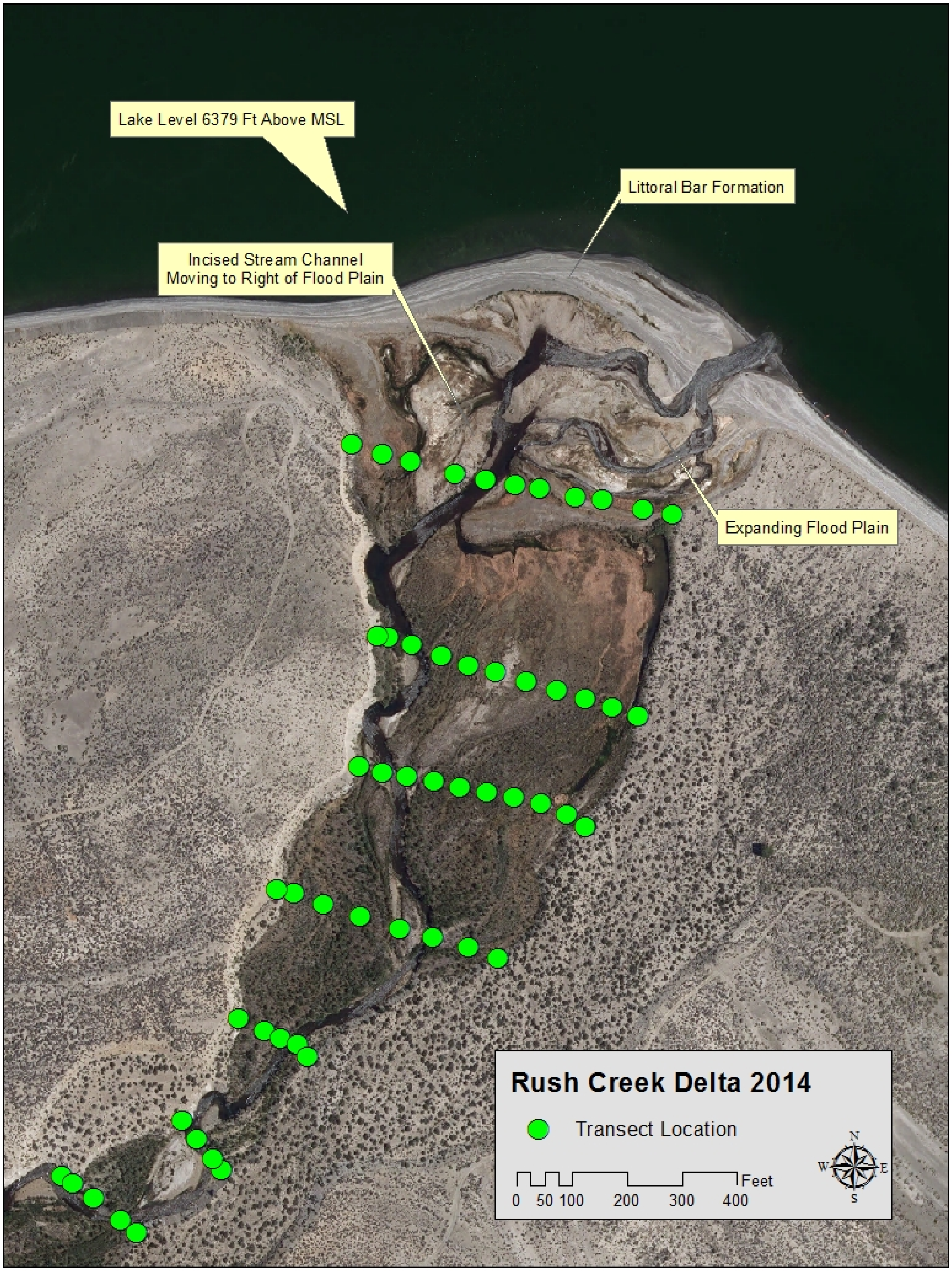


Figure 11. 2014 imagery of Rush Creek Delta.



Appendix 1: 2014 Vegetation Transect Photos

Photos are labeled as Spring Name-Group of Transects-Transect Location-Photo Direction

Dechambeau Embayment (DE) Transect ,1 August 21, 2014

DE-N-100-0-50

DE-N-100-50-0

DE-M-75-S-0-50

DE-M-75-N-50-0

Dechambeau Embayment Transect 1 (Continued)

DE-S-75-N-0-50

DE-S-75-N-50-0

Dechambeau Embayment Transect 2 August 21, 2014

DE-N-50-S-0-50

DE-N-50-S-50-0

DE-M-37.5-S-0-50

DE-M-37.5-S-50-0

Dechambeau Embayment Transect 2 (Continued)

DE-S-25-N-0-50

DE-S-25-N-50-0

Dechambeau Embayment Transect 3 August 21, 2014

DE-N-0-S-0-50

DE-N-0-S-50-0

DE-M-0-S-0-50

DE-M-0-S-50-0

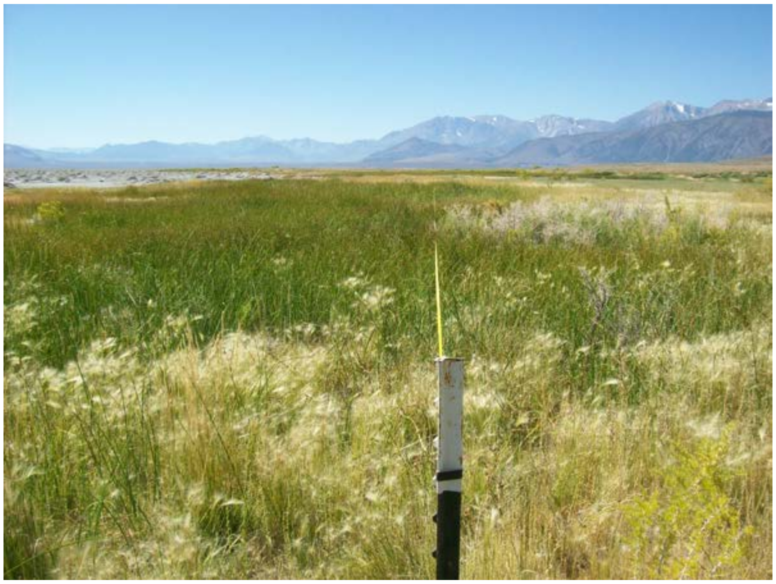
Dechambeau Embayment Transect 3 (Continued)

DE-S-0-S-0-50

DE-S-0-S-50-0

Dechambeau Embayment Transect Comaprison; 2005, 2009, 2014

DE-M-75-S-0-50-2005



DE-M-75-S-0-50-2009

DE-M-75-S-0-50-2014

Warm Springs (WS) Transect 1 August 27, 2014

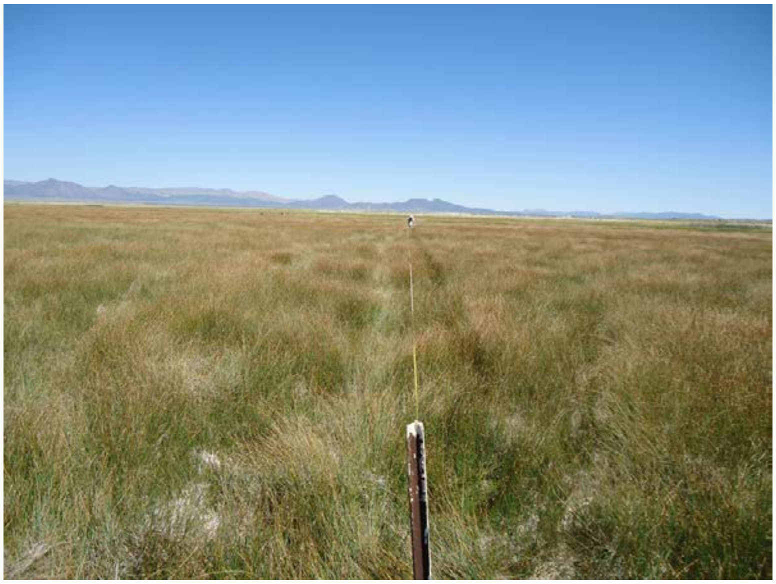
WS-M-250-N-0-50

WS-M-250-N-50-0

WS-N-250-S-0-50

WS-N-250-S-50-0

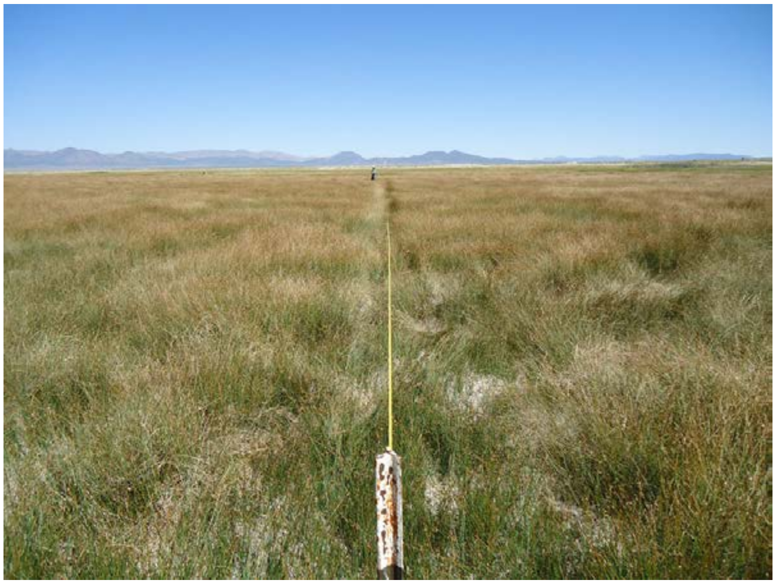
Warm Springs Transect 1 (Continued)



WS-S-225-N-0-50

WS-S-225-N-50-0

Warm Springs Transect 2 August 27, 2014



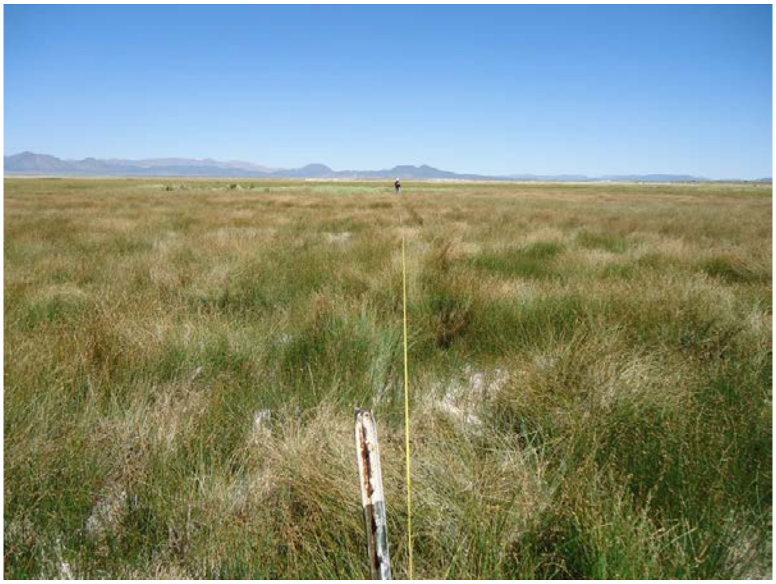
WS-S-200-N-0-50

WS-S-200-N-50-0

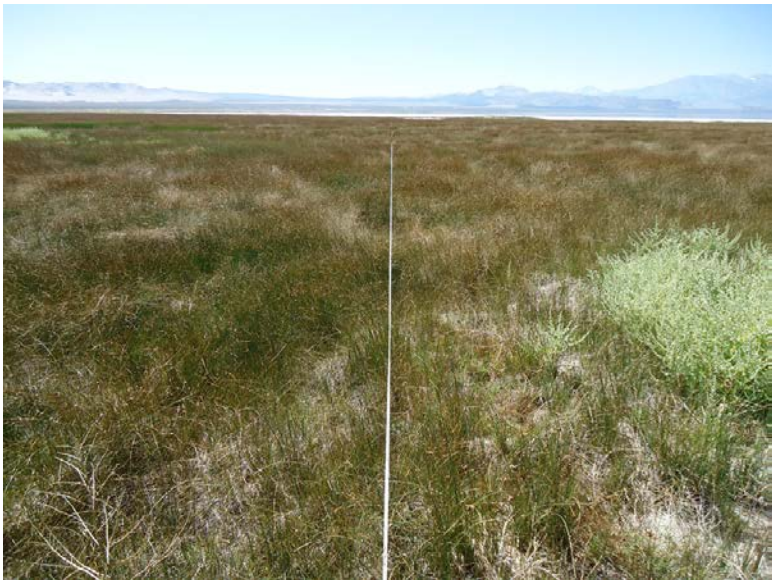
WS-N-200-S-0-50

WS-N-200-S-50-0

Warm Springs Transect 2 (Continued)



WS-M-200-N-0-50



WS-M-200-N-50-0

Warm Springs Transect 3 August 27, 2014

WS-S-100-S-0-50

WS-S-100-S-50-0

WS-N-100-S-0-50

WS-N-100-S-50-0

Warm Springs Transect 3 (Continued)

WS-M-100-S-0-50

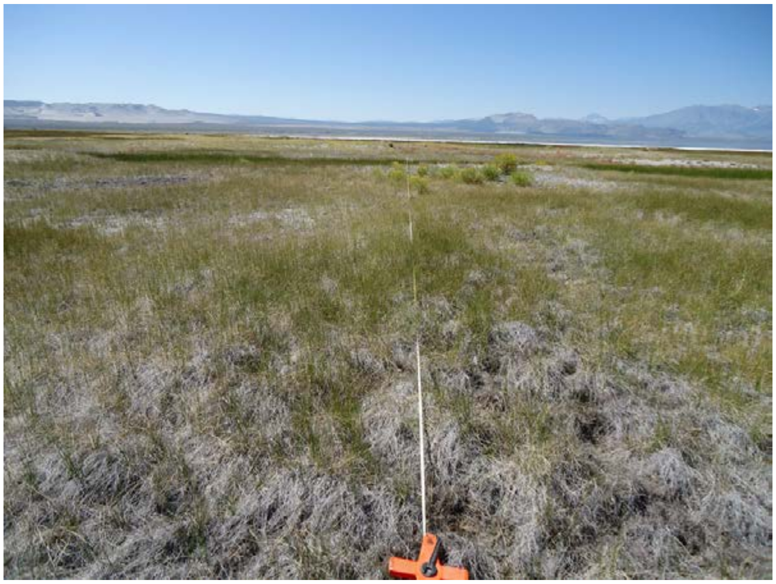
WS-M-100-S-50-0

Warm Springs Transect 4 August 27, 2014

WS-S-0-N-0-50

WS-S-0-N-50-0

WS-N-0-N-0-50



WS-N-0-N-50-0

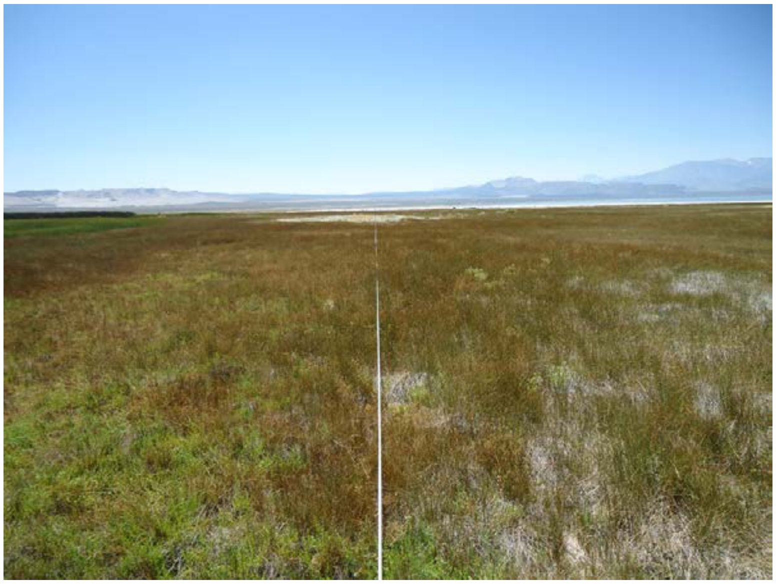
Warm Springs Transect 4 (Continued)

WS-M-0-N-0-50

WS-M-0-N-50-0

Warm Springs Transect 5 August 27, 2014

WS-M-100-NP-0-50

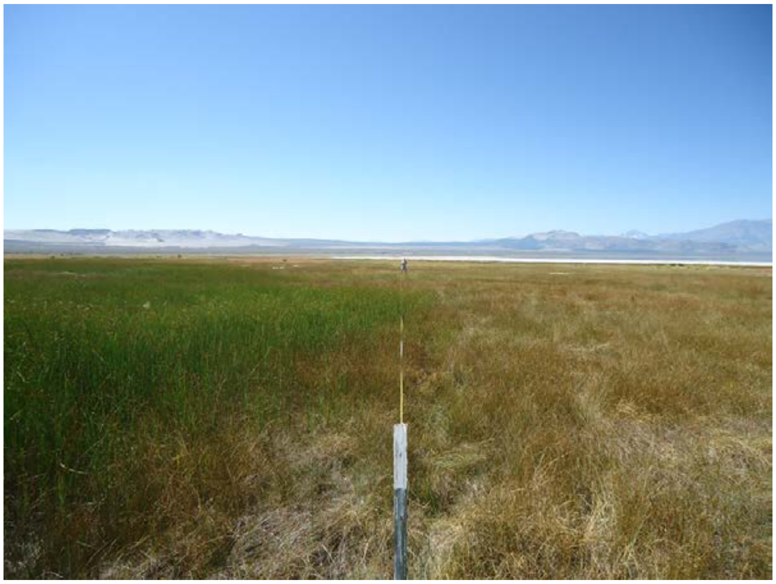


WS-M-100-NP-50-0

WS-N-100-SP-0-50

WS-N-100-SP-50-0

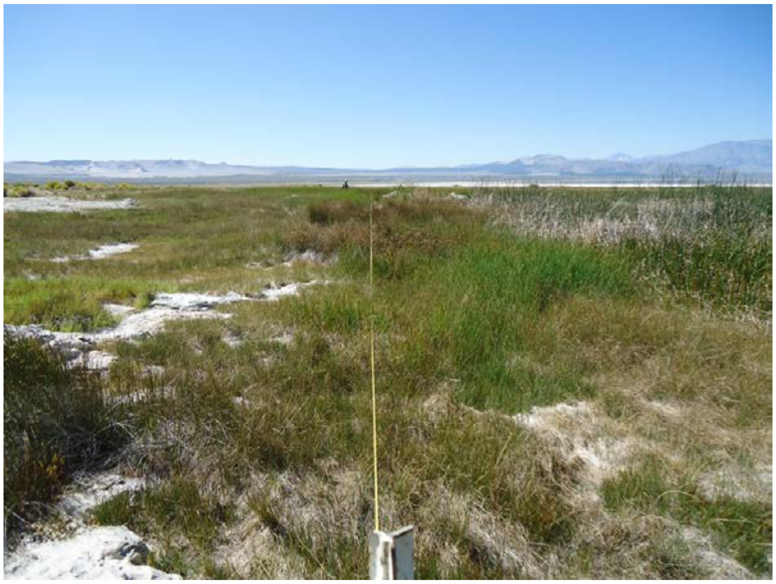
Warm Springs Transect 5 (Continued)



WS-S-100-SP-0-50

WS-S-100-SP-50-0

<u>Warm Springs Transect 6 August 28, 2014</u>



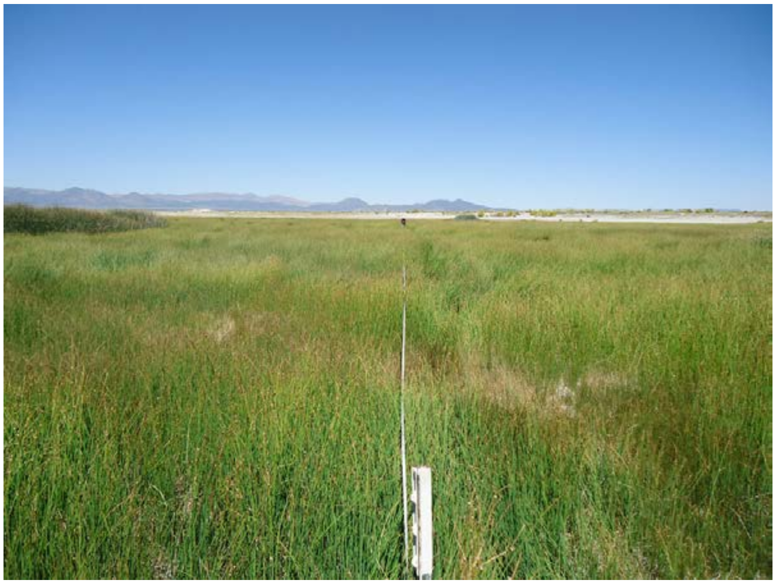
WS-S-200-SP-0-50

WS-S-200-SP-50-0

WS-N-200-SP-0-50

WS-N-200-SP-50-0

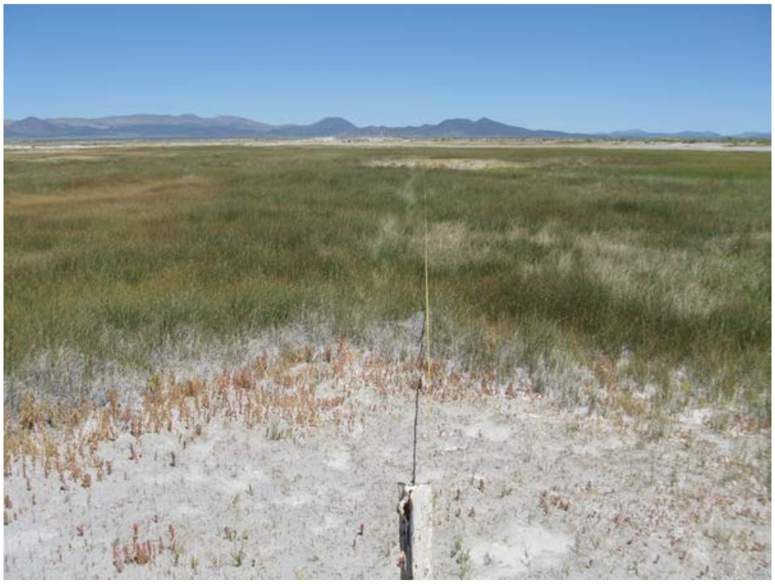
Warm Springs Transect 6 (Continued)



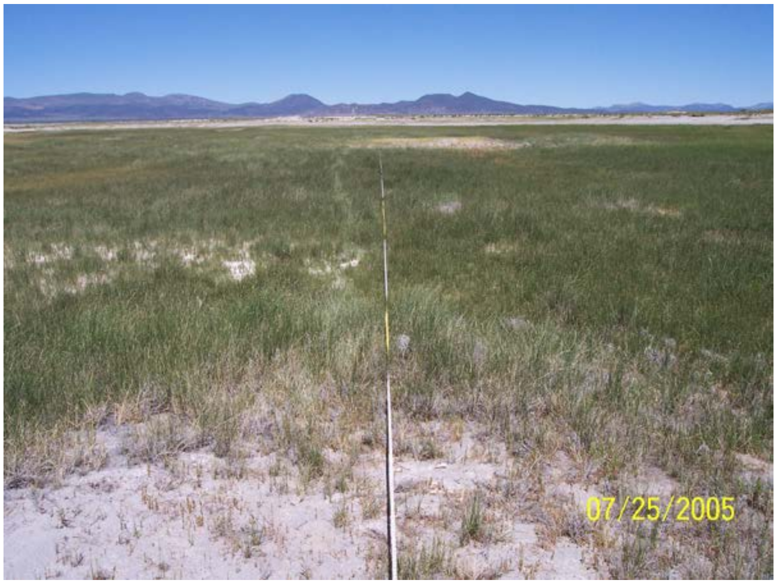
WS-M-200-NP-0-50

WS-M-200-NP-50-0

Warm Springs Transect Comparison; 2005, 2009, 2014



WS-M-100NP-0-50-2005



WS-M-100NP-0-50-2009

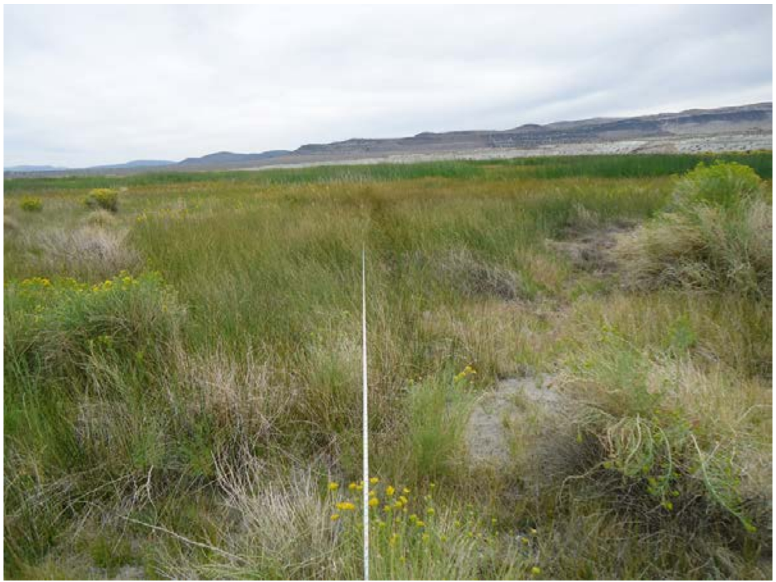
WS-M-100NP-0-50-2014

Sammon Springs (SS) Transect 1 August 28, 2014

SS-1-0-100

SS-1-100-0

Sammon Springs Transect 2 August 28, 2014



SS-2-0-100

SS-2-100-0

Sammon Springs Transect 3 August 28, 2014

SS-3-0-75

SS-3-75-0

Sammon Springs Transect Comparison; 2005, 2009, 2014

SS-1-75-0-2005

SS-1-75-0-2009

SS-1-75-0-2014

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Mueller-Dombois, D. and H. Ellenberg, 2002. Aims and Methods of Vegetation Ecology. The Blackburn Press, Caldwell, New Jersey.

Mono Lake Landtype Inventory
2014 Conditions

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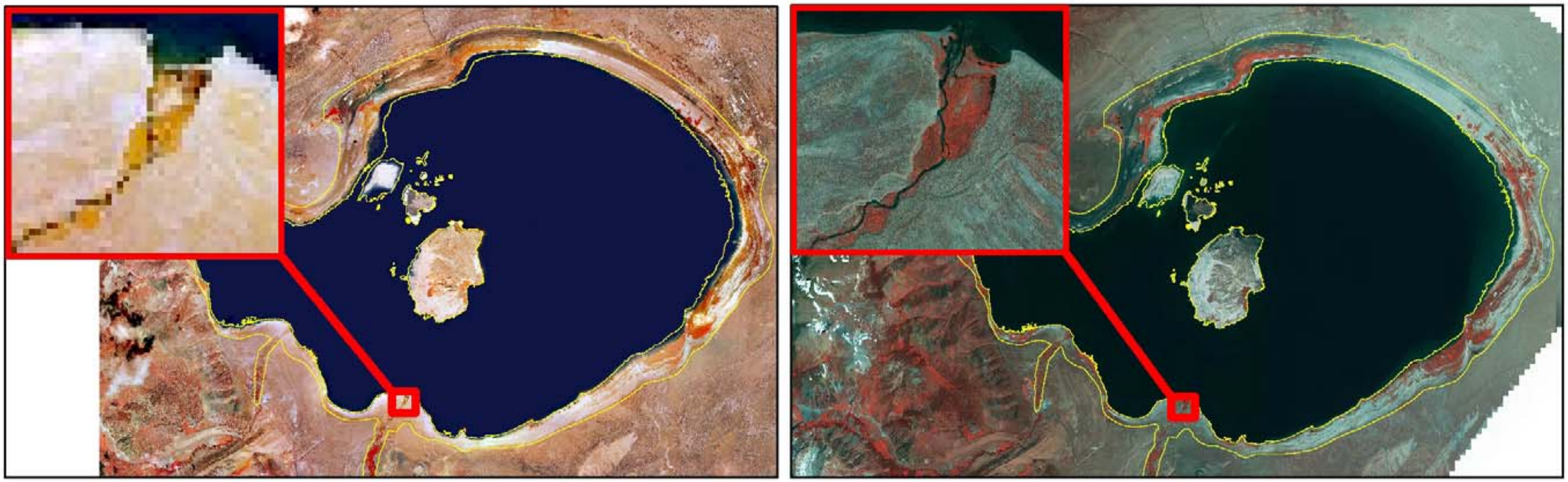
1.0 INTRODUCTION

Los Angeles Department of Water and Power (LADWP) has mapped landtypes surrounding Mono Lake to fulfill State Water Resources Control Board obligations specified in Decision 1631 and Order No. 98-05. The purpose is to monitor changes in the extent of lake fringing wetland as a basis for evaluating waterfowl habitat. Previous mapping has been compiled for three periods:

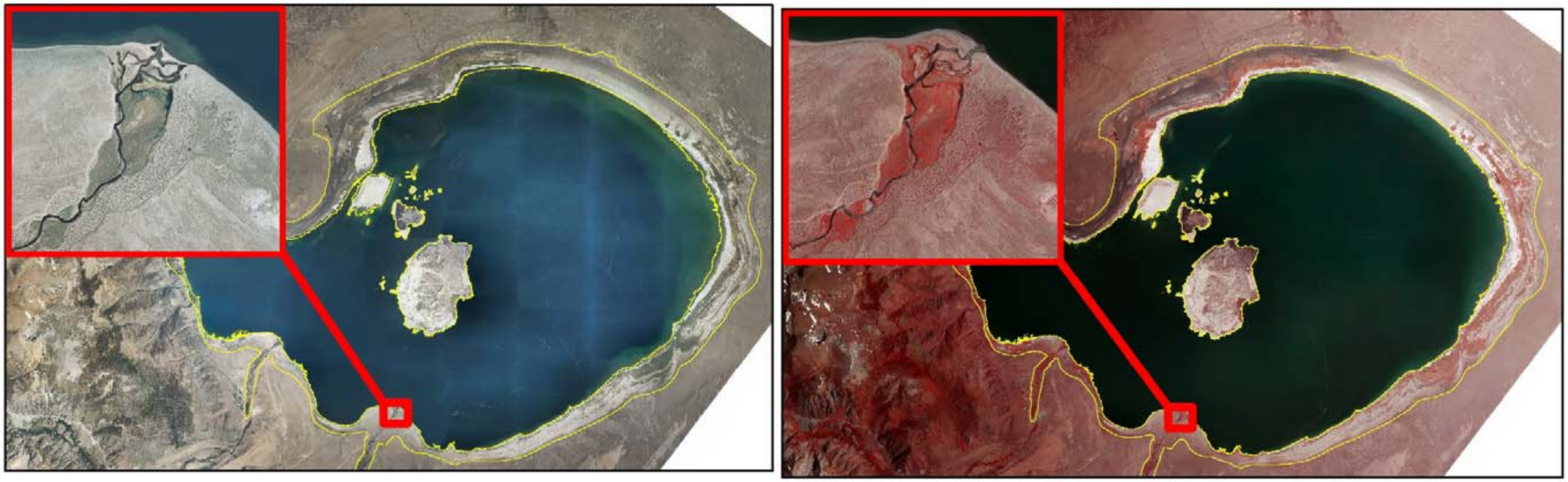
> **September 1999:** Mapping was first compiled from color infrared (CIR) prints that were scanned, mosaicked, and registered (Chapin 2000). The resulting orthophoto was relatively low-resolution (~ 5 m) by today's standard (see Figure 1A). The optimal viewing scale was about 1:3,600. "Heads-up" delineation coupled with field observations were applied to mapping. The 1999 mapping was also evaluated on a higher-resolution 2000 image and the annual changes were found to be insignificant (LADWP 2001).
>
> **August 2005:** Mapping was compiled from a higher-resolution (0.8 m), 4 band satellite image. The optimal viewing scale was about 1:2,000 and afforded more accurate and precise mapping than the previous effort (Figure 1B). "Heads-up" delineation coupled with field observations were applied to mapping (Martin 2006).
>
> **August 2009:** Mapping was compiled for still higher-resolution (0.3 m), 4 band digital orthophoto (Figure 1C). The optimal viewing scale was about 1:1,000. Spectral analysis using ERDAS Imagine software was first applied using supervised classification to identify rasters corresponding with landtype classes. Adjacent rasters of the same class were converted to polygons and imported to ArcMap for subsequent spatial editing. Preliminary products included many millions of very precisely delineated, tiny parcel. A post-classification clean-up was performed to reduce inclusions and correct identifications.

The current effort entails analyses of high-resolution (0.3 m), 4 band digital orthophoto dated July 2014 (Figure 1D). The optimal viewing scale is about 1:1,000. Mapping entailed spectral analysis, conversion of raster classes to polygons, and heads-up editing of polygon features. Improvements of imagery, mapping software, and learned techniques have likely enhanced the accuracy and precision of landtype mapping since 1999.



A) September 1999 conditions.

B) August, 2005 conditions.



C) August 2009 conditions.

A) July 2014 conditions.

Mono Lake Vegetation Mapping Imagery

Figure 1

2.0 METHODS

Mapping was recompiled for 16 subareas along the shore of Mono Lake for 1999, 2005, 2009, and 2014 conditions; it was compiled for 2 tributary subareas for 2009 and 2014 conditions; it was compiled for islands in Mono Lake for 1999 and 2014 conditions. Subareas are identified in Figure 2.

Previous mapping results for 1999, 2005 and 2009 were standardized to reduce minor inconsistencies in the upslope (fixed) boundary and to remove overlap between adjacent subareas. Polygons less than 50 square meters were eliminated from the 2009 mapping.

The 2014 imagery was delivered for ¼, ¼ quads as 4-band, Tagged Image File Format (TIFF) files with 1 foot resolution. Tiles were assembled as a raster mosaic, clipped to the survey area corresponding with all subareas (Figure 2), aggregated from 1 foot to 1 meter pixels, and input to unsupervised spectral classification with 10 classes. Spectral classes were assigned to a distinguishable landtype class that was later correlated to a map class defined for previous mapping. Contiguous rasters of the same class were aggregated and exported as a polygon shapefile. Parcels less than 50 square meters were eliminated and the entire map subjected to heads-up editing based on image interpretation, several days of field review in February 2015, and photographs obtained during aerial bird surveys in 2013 and 2014. Final mapping for 2014 was intersected by subareas.

3.0 RESULTS

The elevation of Mono Lake was 6384.2 feet in September 1999, 6382.6 feet in August 2005, 6381.9 feet in August 2009, and 6380.1 in July 2014. The decline in Mono Lake water surface elevation since 1999 has resulted in an increase in the size of subareas for successive surveys. The lakeshore has increased 1,817 acres from 1999 to 2014 (Table 1) in response to declining lake elevation (Figure 3). The area of islands increased 331 acres for the same period. The area of Mono Lake decreased to the same extent.

A preliminary legend of landtypes for 2014 conditions was based on what could be easily distinguished from the 2014 imagery. These “preliminary” classes were subsequently correlated to more-specific or less-specific “final” classes used for previous inventories (Table 2). The preliminary “water” class was further stratified into six classes (freshwater stream, freshwater pond, ria, ephemeral brackish lagoon, hypersaline lagoon, and mudflat) by personnel familiar with aquatic features on the lake margin (Debbie House). Preliminary rabbitbrush/meadow was correlated to dry meadow/forb[1] due to its ranking on the dry extreme of meadow habitat. Extensive upland scrub and rabbitbrush scrub, and less extensive eolian deposit preliminary landtypes were correlated to the more general Great Basin scrub landtype. Barren lake bed and streambar preliminary landtypes were correlated to the more general unvegetated landtype. Other preliminary landtypes were similar to previously identified landtypes.

Results are further discussed with respect to lake-margin subareas, tributary subareas, and the island subarea, respectively. The area of landtypes by subarea for 1999, 2005, 2009, and 2014 are listed in APPENDIX A. Maps of landtypes for 2014 conditions are included as APPENDIX B. Photographs of landtypes are in APPENDIX C. A historical view of 1999, 2005, 2009, and 2014 conditions is included as APPENDIX D.

---

[1] During field reconnaissance in February 2015, I found nothing resembling the description for dry meadow/forb.

Mono Lake Map Subareas

Figure 2

Table 1. Area of subareas by year.

Subarea	Area (acres)			
	2014	2009	2005	1999
LAKESHORE SUBAREAS				
South tufa	331	313	311	299
South shore lagoon	1298	1244	1245	1172
Sammonn Spring	1199	1130	1119	1036
Sammonn Spring east	664	621	602	541
Warm Spring	1629	1442	1406	1274
Northeast shore	2492	2407	2430	2373
Bridgeport Creek Delta	1458	1352	1347	1243
Dechambeau Embayment	1632	1555	1536	1418
Black Point	1014	887	829	740
Mill/Wilson Creek Deltas	513	505	493	480
Dechambeau Creek Delta	214	203	201	191
West shore/Lee Vining Delta	681	695	628	598
Lee Vining tufa	122	117	113	112
Ranch Cove	218	212	209	205
Rush Creek Delta	691	787	664	657
TOTAL	**14157**	**13469**	**13132**	**12340**
TRIBUTARY SUBAREAS				
Rush Creek	906	906	--	--
Lee Vining Creek	210	210	--	--
TOTAL	**1117**	**1117**	**--**	**--**
ISLANDS				
Islands	2627	--	--	2296

Table 2. Landtype Correlation

Preliminary	Final
Water	Freshwater stream
	Freshwater pond
	Ria
	Ephemeral brackish lagoon
	Hypersaline lagoon
	Mudflat
Marsh	Marsh
Wet meadow	Wet meadow
Alkali meadow	Alkaline wet meadow
Rabbitbrush/meadow	Dry meadow/forb
Riparian shrub	Riparian shrub
Riparian woodland	Riparian woodland
Upland scrub	Great Basin scrub
Rabbitbrush scrub	
Eolian deposit	
Barren lake bed	Unvegetated
Streambar	
Developed	Man-made

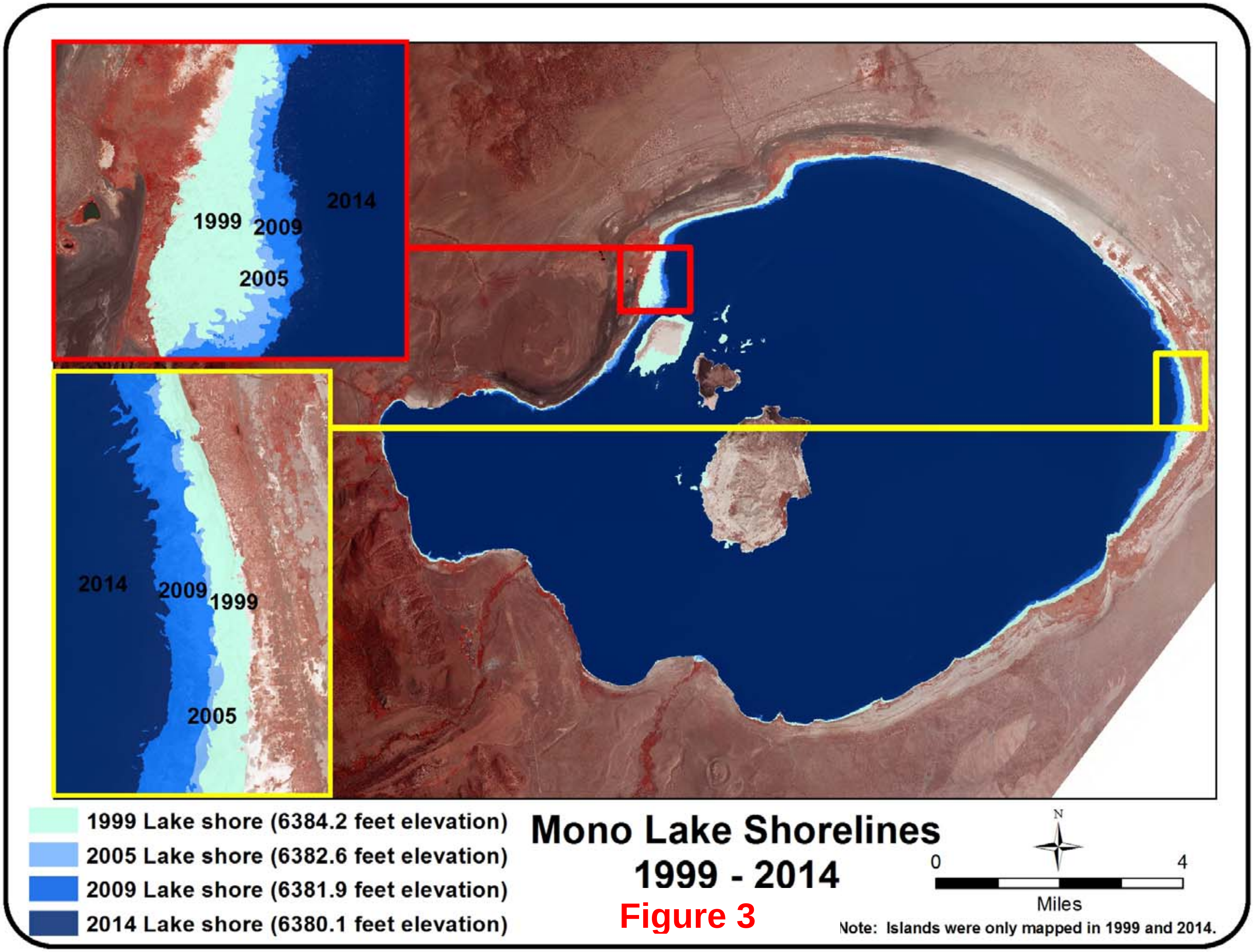

1999
2009
2014
2005
2014
2009
1999
2005
1999 Lake shore (6384.2 feet elevation)
2005 Lake shore (6382.6 feet elevation)
2009 Lake shore (6381.9 feet elevation)
2014 Lake shore (6380.1 feet elevation)
Mono Lake Shorelines
1999 - 2014
N
0
4
Miles
Note: Islands were only mapped in 1999 and 2014.

Figure 3

3.1 Lake-Margin Subareas

Lake-margin subareas were mapped in 1999, 2005, 2009, and 2014. Final landtype classes were mostly those used for 1999, 2005, and 2009 mapping. An additional class (mud flat) was added. The classes were originally selected to be: 1) compatible with previous vegetation mapping; 2) distinctive relative to waterfowl habitat values; and 3) distinguishable from imagery. Brief descriptions of landtype classes, updated for 2014 conditions, follow.

Water: Comprised 95 acres of the lake-margin subareas in 2014. The area of water increased relative to 2009 and 2005, but decreased relative to 1999 (Figure 4). These include freshwater features (Figure 5) and brackish water features (Figure 6).

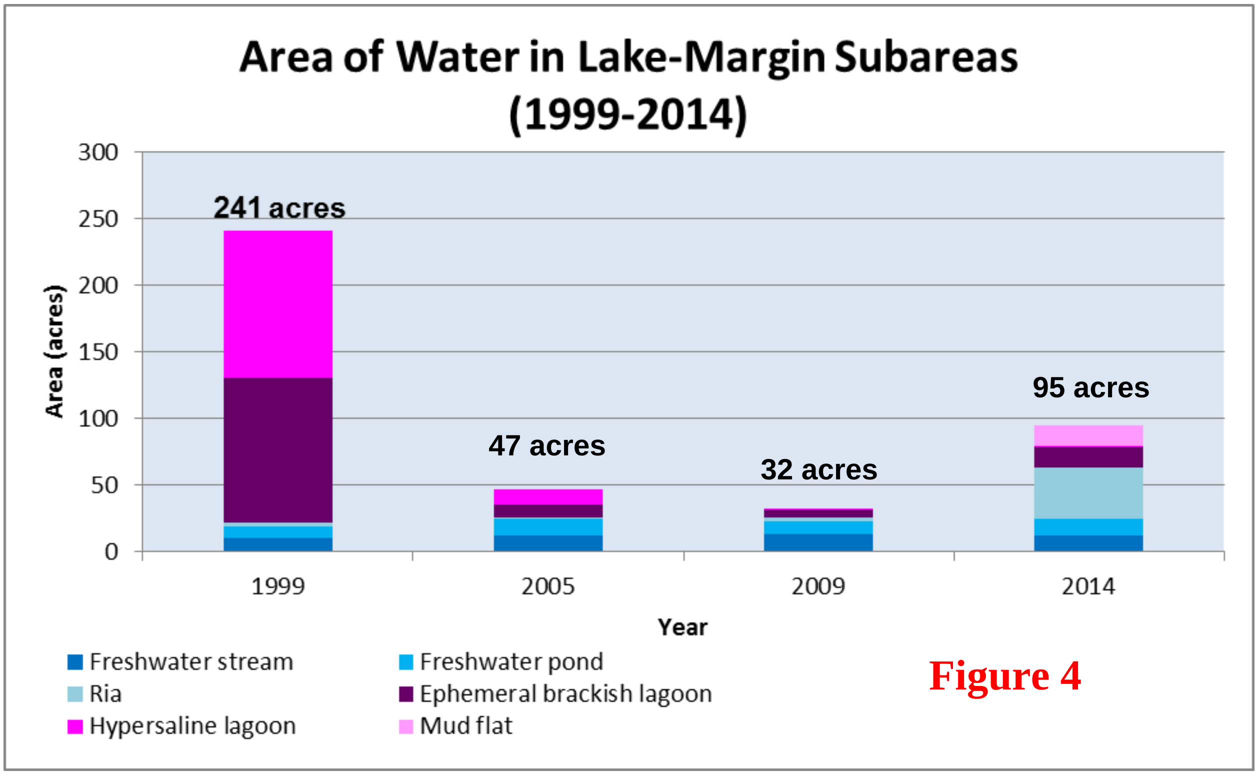


Figure 4

Freshwater Stream: Tributary streams flowing to Mono Lake. Includes lowest portions of Rush[2], Lee Vining, Dechambeau, Mill, and Wilson Creeks not shrouded by vegetation that are discernible on imagery. Areas remained relatively consistent from 1999 to 2014.

Freshwater Pond: Ponds fed by springs within marsh areas or artificially with stream diversions (*e.g*. DeChambeau/County ponds). Areas remained relatively consistent from 1999 to 2014.

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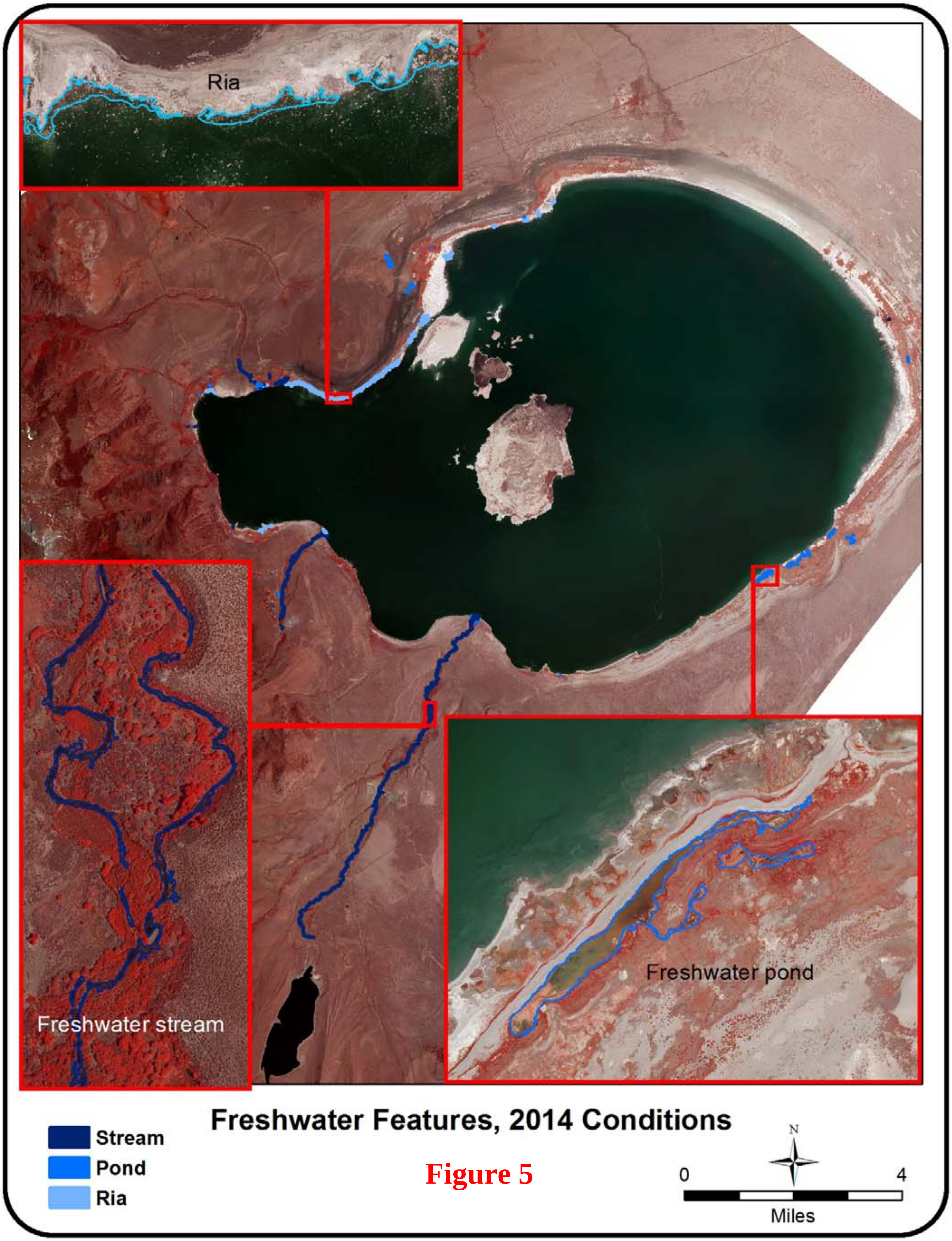
[2] The areas of freshwater stream in tributary subareas are reported separately than those in lake-margin subareas reported here.



Freshwater Features, 2014 Conditions

Figure 5

Brackish Features, 2014 Conditions

Figure 6

Freshwater Ria: Surface water at the mouths of streams that likely has some salt/fresh water stratification. Only a few rias totaling less than 3 acres were identified in 1999, 2005 and 2009; but 72 areas totaling 39 acres were identified in 2014, including many small areas with direct connection to Mono Lake. Freshwater rias may not have been delineated consistently in 2014; they could not be spectrally distinguished from ephemeral brackish lagoon or hypersaline lagoon. Results should be viewed skeptically.

Ephemeral Brackish Lagoon: Lagoons separated from Mono Lake by littoral bars that receive drainage from upslope marsh and wet meadow sustained by springs. The area of this type decreased from 109 acres in 1999 to less than 15 acres in subsequent years. These features were not delineated consistently in 2014; they could not be spectrally distinguished from ria or ephemeral hypersaline lagoon. Results should be viewed skeptically.

Ephemeral Hypersaline Lagoon: Lagoons separated from Mono Lake by littoral bars that appear to lack a freshwater source. These areas contain concentrated brine due to evaporation. The area of this type decreased from 111 acres in 1999 to 24 acres in 2005. It comprised less than an acre in 2009 and 2014. These features were not mapped consistently in 2014; they could not be distinguished from ria or ephemeral brackish lagoon. Results should be viewed skeptically.

Mud flat: Wet substrate, shallow water, and algae within recent drawdown zone along the lake margin. About 15 acres of this type was identified in 2014. Again, in was mapped somewhat inconsistently.

Marsh/Meadow: In 2014 marsh and meadow landtypes totaled 2,710 acres in the lake-margin subareas. Similar total areas were identified in previous years (Figure 7). Individual marsh/meadow landtypes occur as complex associations with diffuse boundaries that were difficult to distinguish from imagery, or even on the ground. Four landtypes were identified (Figure 8).

Herbaceous landtype classes were not easily distinguishable from the 2014 images. Marsh, wet meadow, alkaline wet meadow, and dry meadow/forb were assigned to successively drier herbaceous habitats; boundaries were typically diffuse and spectral signatures were broadly overlapping. Results for individual marsh/meadow landtypes should be viewed skeptically. Results for the sum of marsh/meadow landtype classes may be more comparable to previous inventories.

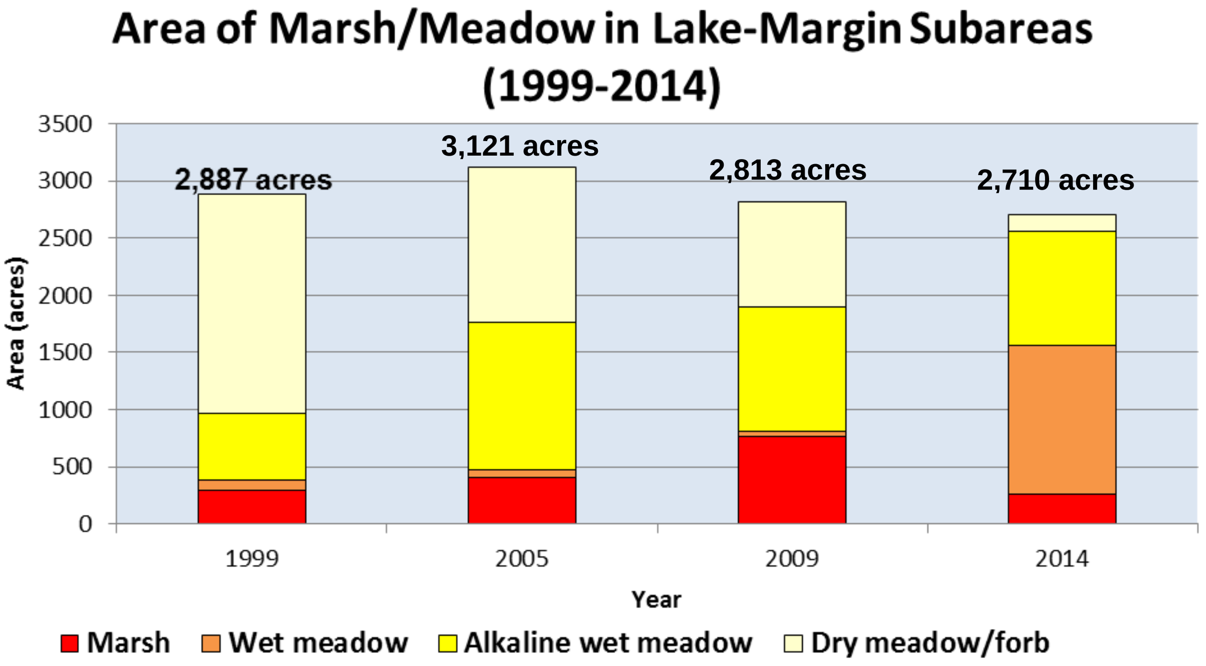
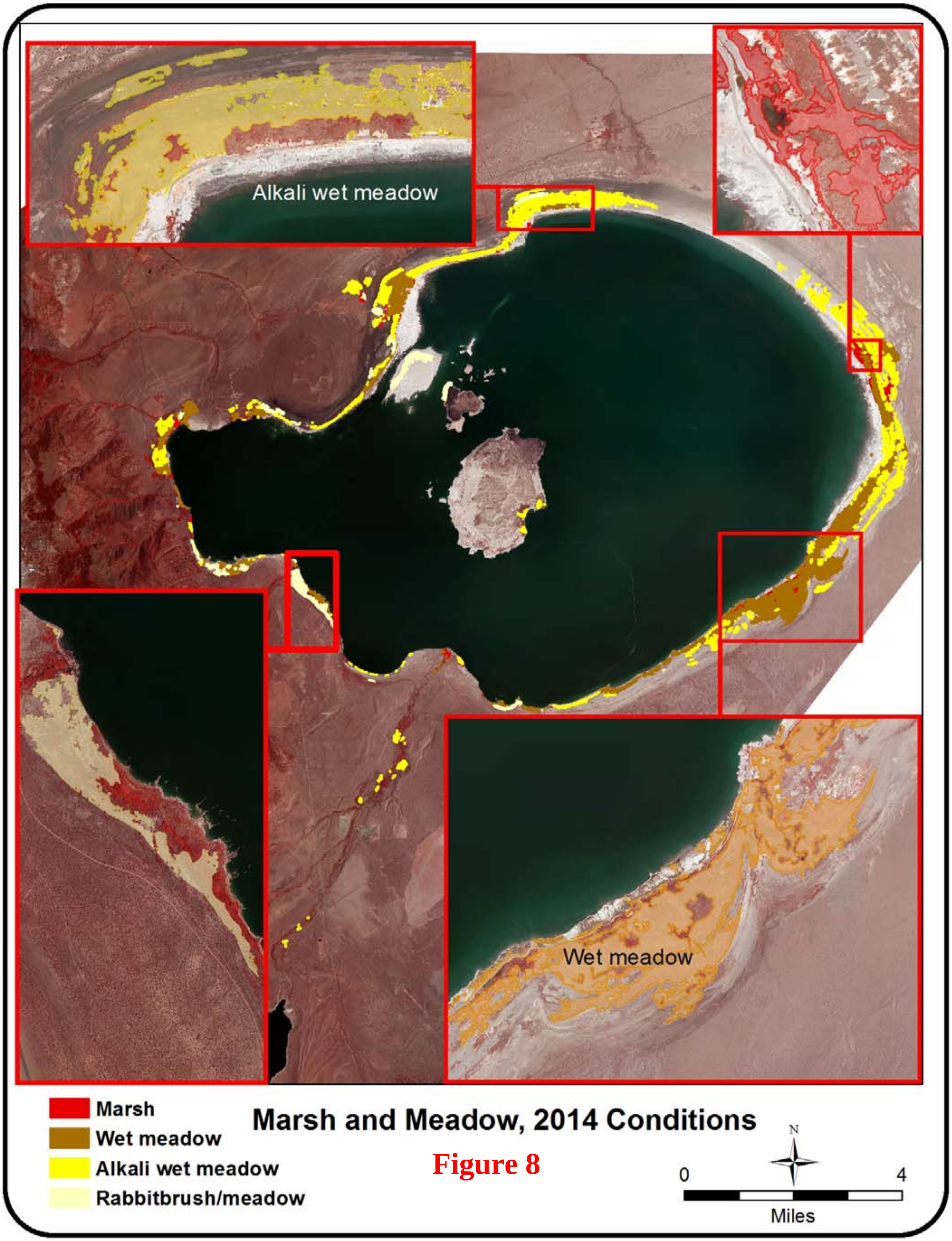


Figure 7



Marsh and Meadow, 2014 Conditions

Figure 8

Marsh: Saturated and permanently flooded habitat dominated by obligate hydrophytic plant species. Prominent species include hard-stem bulrush (*Schoenoplectus acutus*), cattail (*Typha latifolia*), and three square (*Schoenoplectus americanus*). Marsh occurs in association with semi-permanently flooded wet meadow, seasonally flooded alkali wet meadow, and dry meadow/forb landtypes; boundaries are sometimes diffuse and difficult to distinguish from imagery. The area of marsh appears to have increased from 300 acres in 1999 to 766 acres in 2009, and then decreased to 256 acres in 2014. In 2014 small parcels of marsh surrounded by more extensive wet meadow were delineated in the Sammonn Spring subarea (Figure 9A)[3]. Inclusions of marsh in wet meadow and areas transitional from wet meadow to marsh were observed (Figure 10). The same area appears wetter on the 2009 image and most of the area was mapped marsh (Figure 9B)[4]. Brown areas on the 2009 image correspond with areas of Baltic rush, a prominent component of wet meadow, in 2014. The decline in marsh in 2014 is attributed more to differences in the spectral character of imagery[5] and to inconsistent mapping[6], than to reduction in the extent of marsh vegetation.

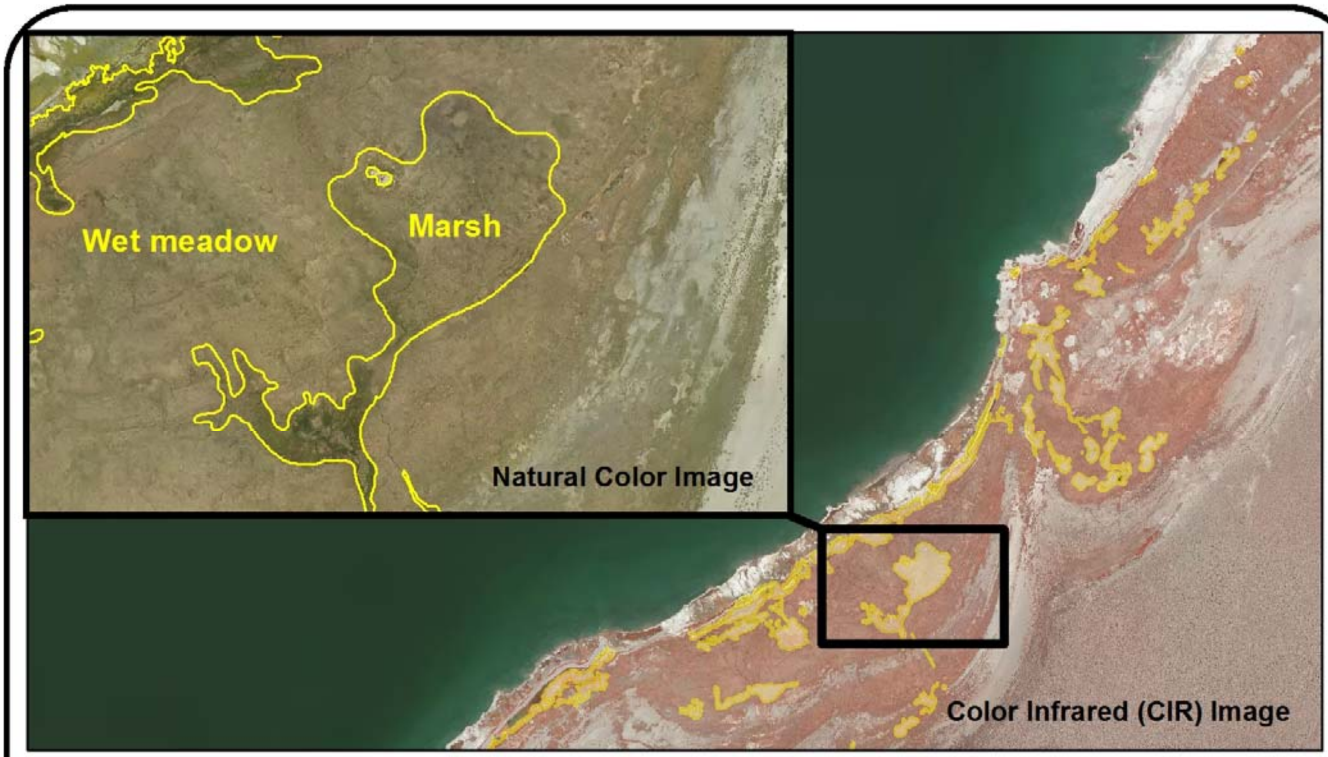
---

[3] Marsh and wet meadow in the Sammonn Spring subarea were verified in 2014.

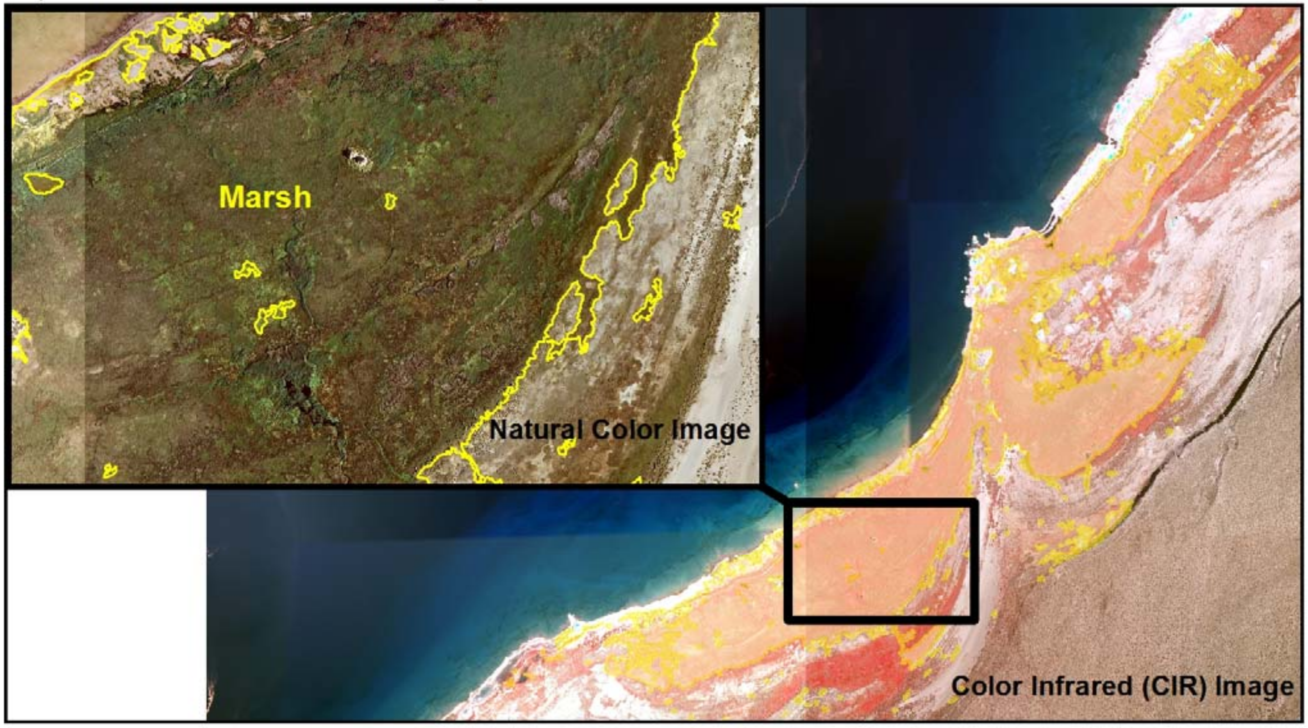
[4] The brown areas on the 2009 image correlate with areas of

[5] Note the difference in spectral character between adjacent tiles of the 2009 image.

[6] ERDAS Imagine software was used for spectral analyses in 2009 and ArcMap Spatial Analyst in 2014.



A) Marsh identified on 2014 imagery.



B) Marsh identified on 2009 imagery.

Extent of Marsh in Sammonn Spring Subarea
2014 versus 2009 Conditions

Figure 9

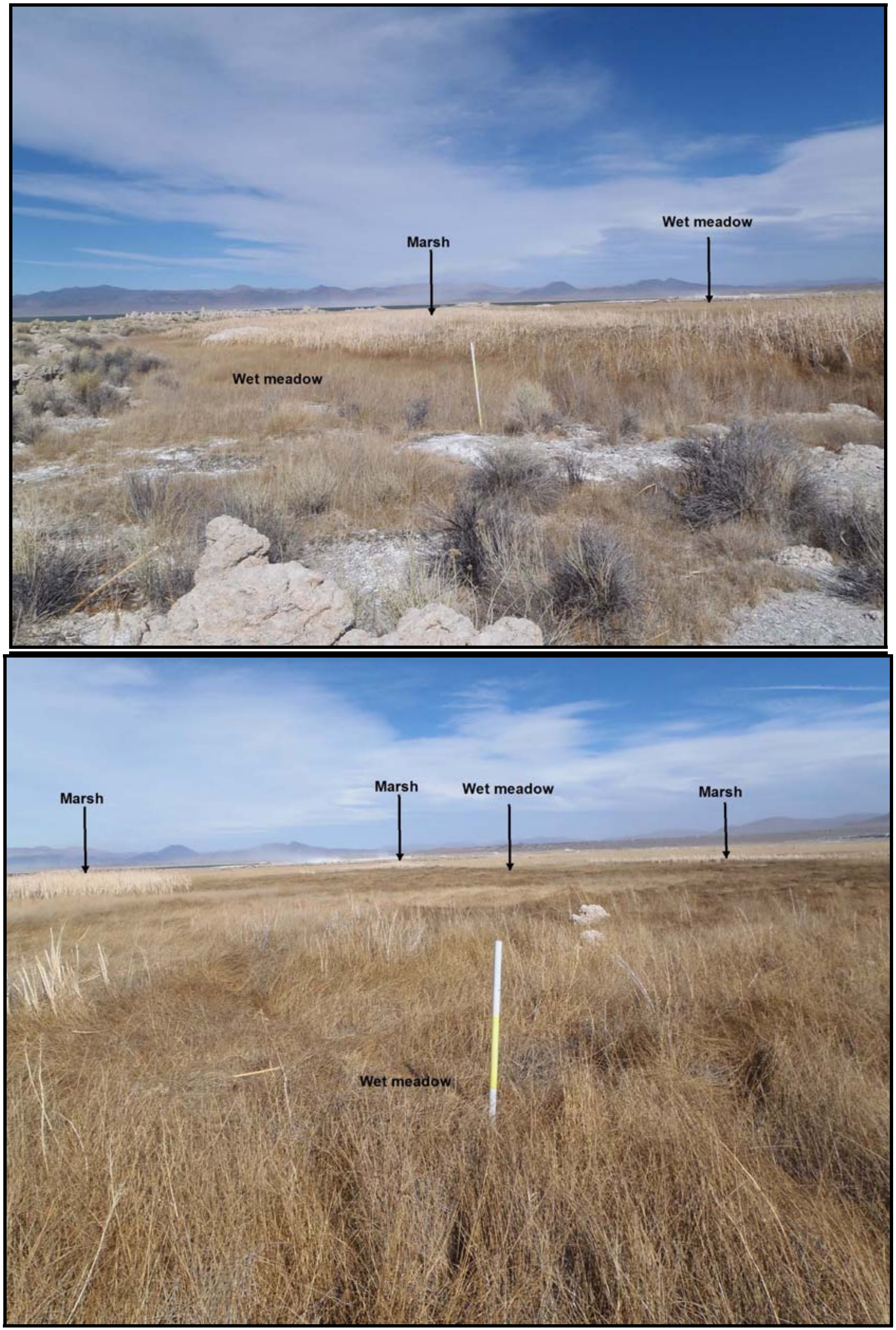


Figure 10. Wet meadow and marsh in the Sammonn Spring subarea.

Wet Meadow: Semi-permanently flooded habitat dominated by obligate and facultative wetland plant species. Prominent species include rushes (*Juncus* spp.), spikerushes (*Eleocharis* spp.), saltgrass (*Distichlis spicata*) and sedges (*Carex* spp.). Wet meadow occurs in association with marsh, alkali wet meadow, and dry meadow/forb landtypes; boundaries may be diffuse and difficult to distinguish from imagery. Prior to 2014, wet meadow was identified where alkaline or saline soils were not evident. Less than 85 acres of wet meadow were identified in 1999, 2005 and 2009; 1,301 acres was identified in 2014. While there may be a subtle trend towards wetter meadow conditions, the large increase in 2014 is likely a response to inconsistent mapping of marsh, wet meadow, and wet alkali meadow. Large areas of wet meadow delineated in 2014 were identified as marsh (Figure 9) or alkali wet meadow in previous mapping efforts. The increase in wet meadow in 2014 is attributed to differences in the spectral character of imagery, the difficulty distinguishing wet meadow from other meadow landtypes, and possibly an increase in the extent of wet meadow vegetation.

Alkali Wet Meadow: Seasonally flooded habitat and areas with high water table dominated by facultative wetland plant species. Prominent species include saltgrass (*Distichlis spicata*) and Baltic rush (*Juncus arcticus*) with nearly total canopy cover. Alkali wet meadow occurs in association with marsh, wet meadow and dry meadow/forb; boundaries may be diffuse and alkali wet meadow is difficult to distinguish consistently on imagery. Prior to 2014, this landtype was distinguished by the presence of alkali and/or saline soil; possibly because of the high vegetation cover, alkali/saline soils were not evident in 2014[7]. The area of alkali wet meadow was 582 acres in 1999, 1,293 acres in 2005, 1,095 acres in 2009, and 1,000 acres in 2014. Although the net areas are similar, the areas of alakali wet meadow for one year may not be the same as those for subsequent years. These differences are ascribed to more differences in the spectral character of imagery, difficulty distinguishing alkali wet meadow for associated meadow landtypeskali wet meadow vegetation, than to changes in the extent of alkali wet meadow.

Dry Meadow/Forb: Relatively dry habitat dominated by facultative wetland and facultative upland plant species. Prior to 2014, this landtype was meant to include a variety of grasses and forbs with relatively low canopy cover. Forbs were not evident in February 2014. Areas of rabbitbrush/meadow that falls in a similar hydrologic regime were included in 2014 mapping. The area of dry forb meadow decreased from 1,922 acres in 1999 to 152 acres in 2014, possibly reflecting a trend towards wetter meadow conditions. Most of the area mapped dry meadow/forb in 2009 was identified as alkali wet meadow, wet meadow, and marsh in 2014. These large differences may be attributed more to differences in the spectral character of imagery, inconsistent mapping, and difficulty distinguishing dry meadow/forb from other meadow types than to a change in the extent of dry meadow/forb vegetation.

---

[7] Given the underlying landform is an alkali lake bed, it seems logical that saline/alkali soil are prevalent throughout the lake margin map area.

Riparian: Riparian shrub and woodland in lake-margin subareas comprised between 226 and 446 acres between 1999 and 2014 (Figure 11). Most riparian landtypes were concentrated along the west shoreline (Figure 12). Differences between years may reflect a degree of mapping inconsistency.

Results show an 85 percent increase in the area of riparian (shrub and woodland) landtypes between 2009 and 2014. Examination of the differences between the two years indicates the increase is more a response to more precise delineation of shrub/tree canopies in 2009 and inclusion of more intra-canopy space in 2014.

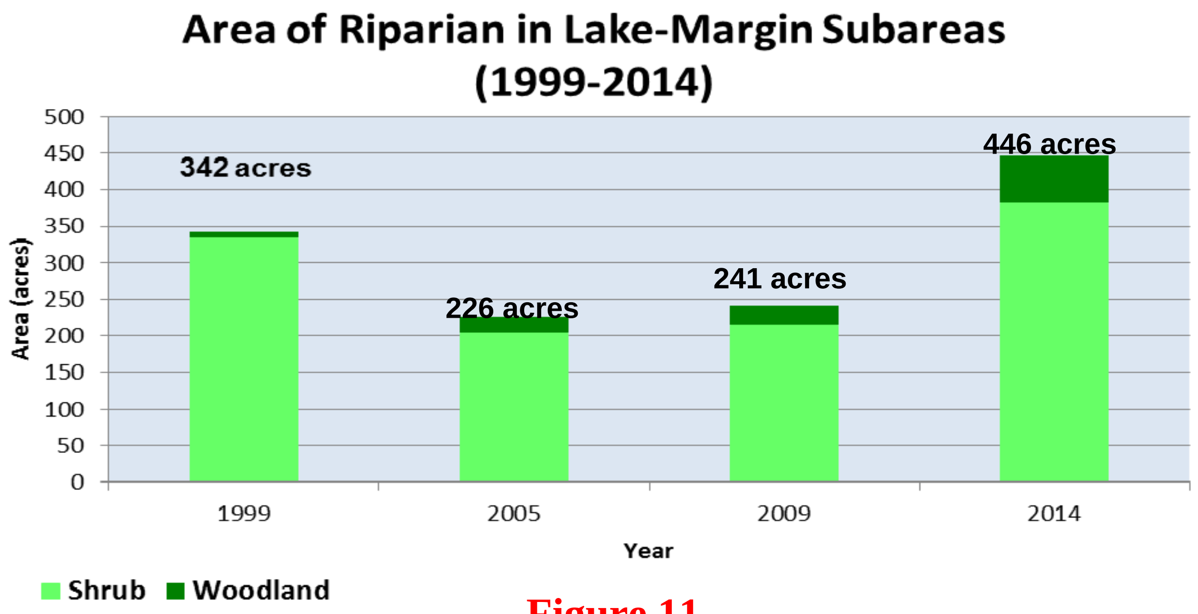
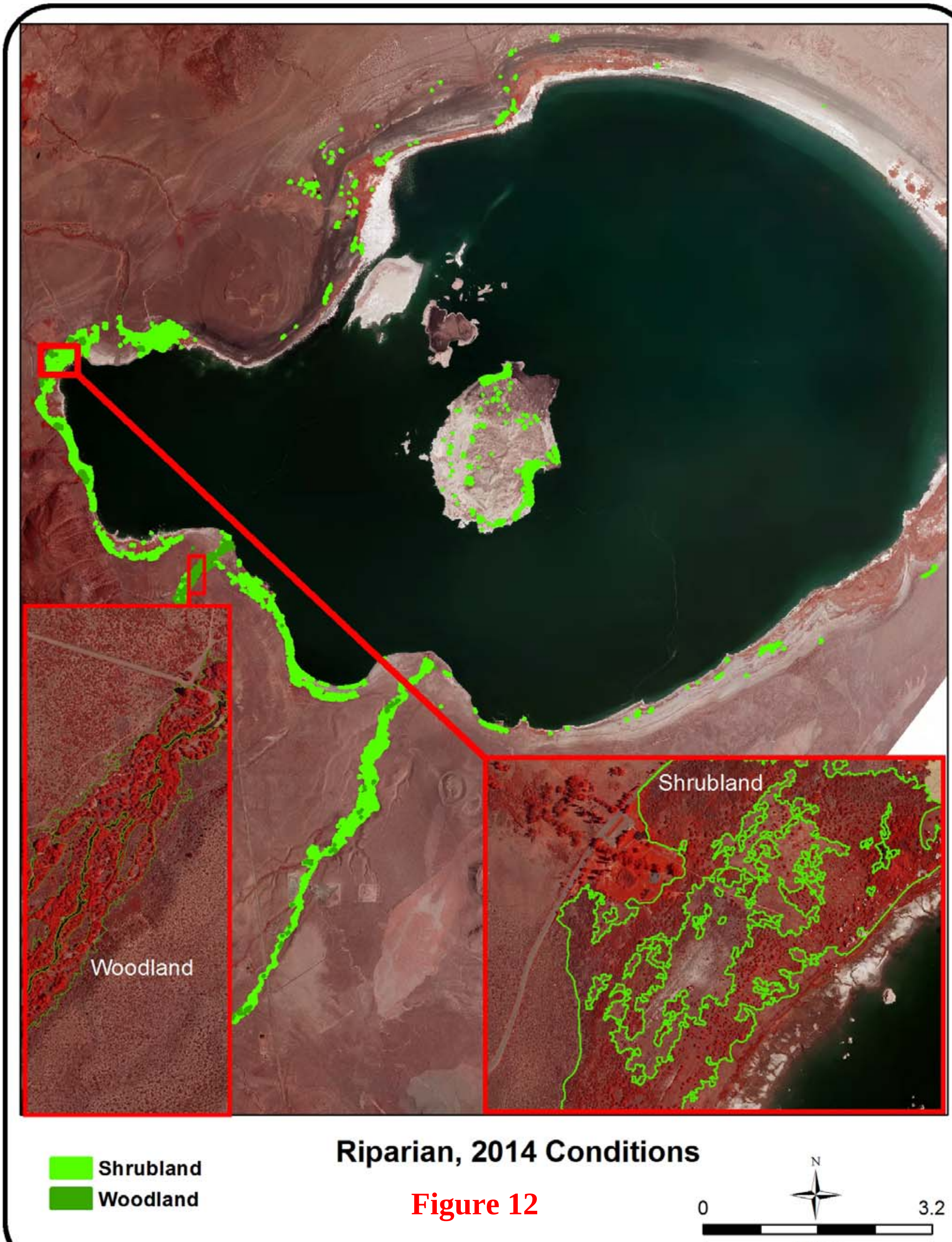


Figure 11

Riparian shrub: Seasonally flooded areas dominated hydrophytic shrubs. Prominent plants include willow (*Salix* spp.), buffalo berry (*Shepardia argentea*) and Wood's rose (*Rosa woodsii*). Small areas of Great Basin scrub and meadow landtypes are included.

Riparian Woodland: Typically transitional from seasonally flooded riparian towards moist upland. Aspen (*Populus tremuloides*), and black cottonwood (*Populus balsamifera*) are typically prominent; Jeffrey pine (*Pinus jeffreyi*) is often present. Riparian woodland is prominent along Lee Vining Creek.



Riparian, 2014 Conditions

Figure 12

Scrub: A singular upland scrub type (Great Basin scrub) was identified in 1999, 2005, and 2009. Upland scrub was further distinguished as four landtypes in 2014 (Figure 13). Scrub landtypes comprise 4,905 acres of the 2014 map area (Figure 14).

Comparisons of 2014 scrub landtypes show an increase of 22 percent since 1999 and 69 percent since 2009. Prior to 2014, much of the rabbitbrush scrub on the lake bed was included as unvegetated landtype. Rabbitbrush scrub is difficult to distinguish from barren lakebed and boundaries are very complex.

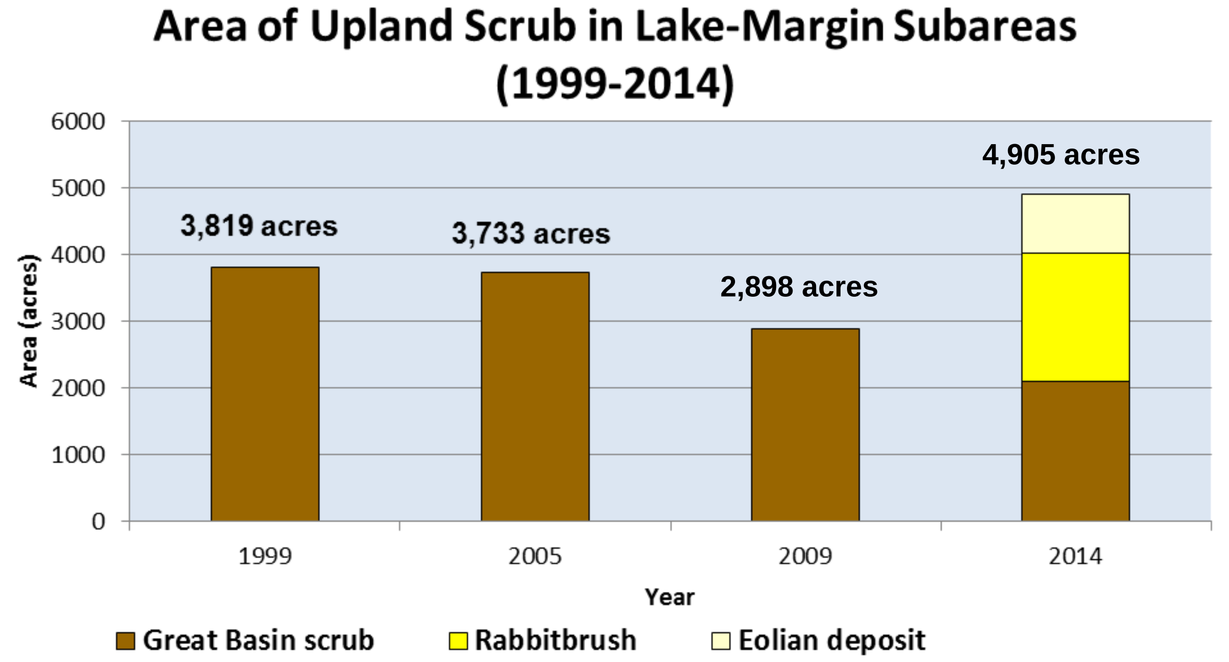


Figure 13

Great Basin scrub: Upland scrub dominated by sagebrush (*Artemisia tridentata*) and bitterbrush (*Purshia tridentata*) with scant understory. Occurs primarily on the upslope margin of the lake bed on terrace. Areas mapped in 1999, 2005 and 2009 included *rabbitbrush scrub* and *eolian deposit*. In 2014, a total of 2,100 acres was identified.

Rabbitbrush scrub: Upland scrub dominated by rabbitbrush (*Ericameria nauseosa*) with scant understory. Most areas of rabbitbrush were previously mapped as *unvegetated* or *Great Basin scrub*. Rabbitbrush occurs in association with barren lake bed and dry meadow/forb; boundaries are typically complex and difficult to distinguish.

Eolian deposit: Low dunes and sand sheets, typically with a sparse scrub canopy and sparse saltgrass understory. It occurs in association with barren lake bed. About 893 acres was identified, mostly along the upslope margin, in 2014. It was included as *Great Basin scrub* or *unvegetated* in previous mapping.

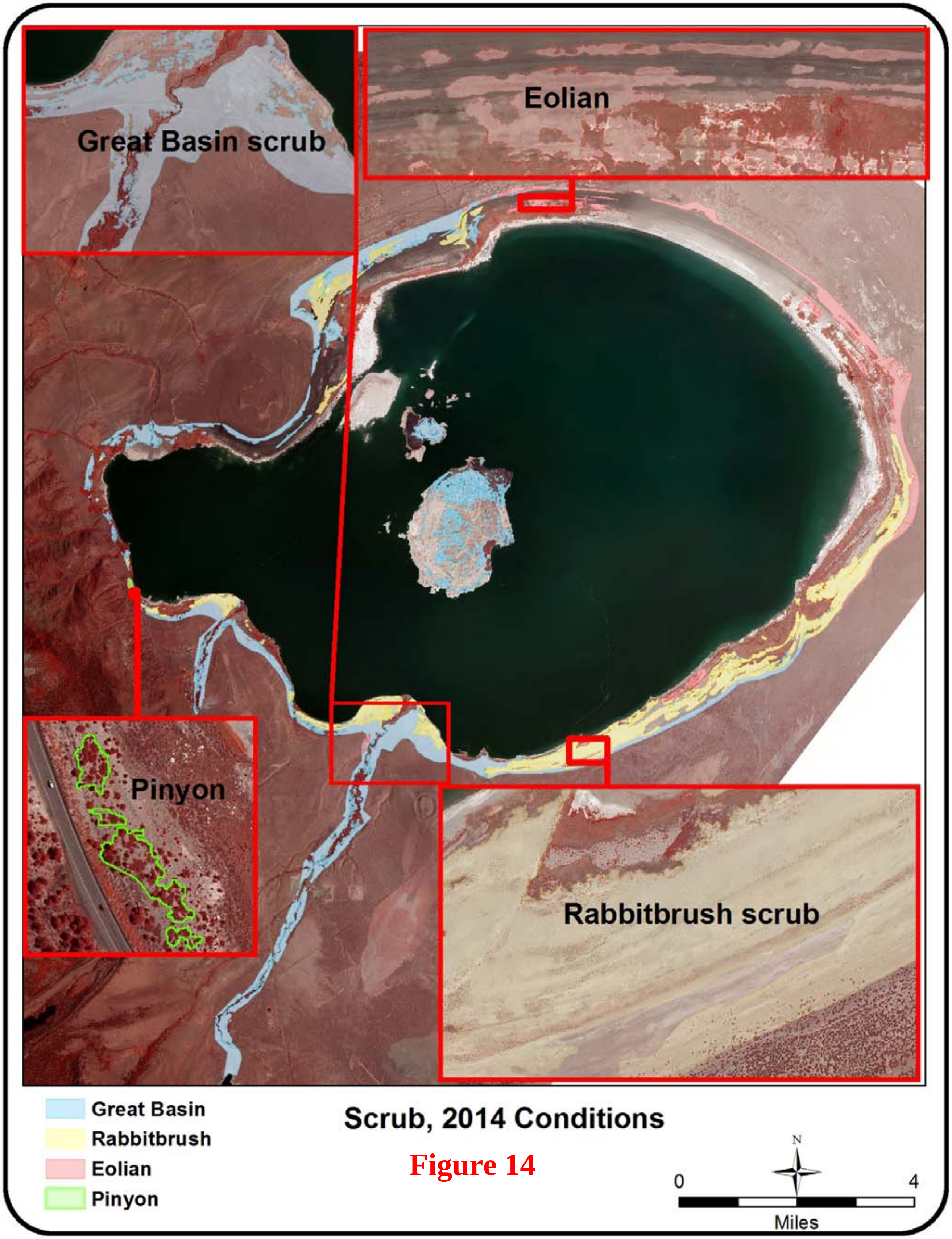

Great Basin scrub
Eolian
Pinyon
Rabbitbrush scrub
Great Basin
Rabbitbrush
Eolian
Pinyon
Scrub, 2014 Conditions
N
0
4
Miles

Figure 14

Barren: Prior to 2014, unvegetated and man-made landtypes were identified (Figure 15). In 2014, unvegetated was partitioned into barren lake bed and streambar (Figure 16). The decline in the area of barren lake bed in 2014 is the area of rabbitbrush scrub included previous years.

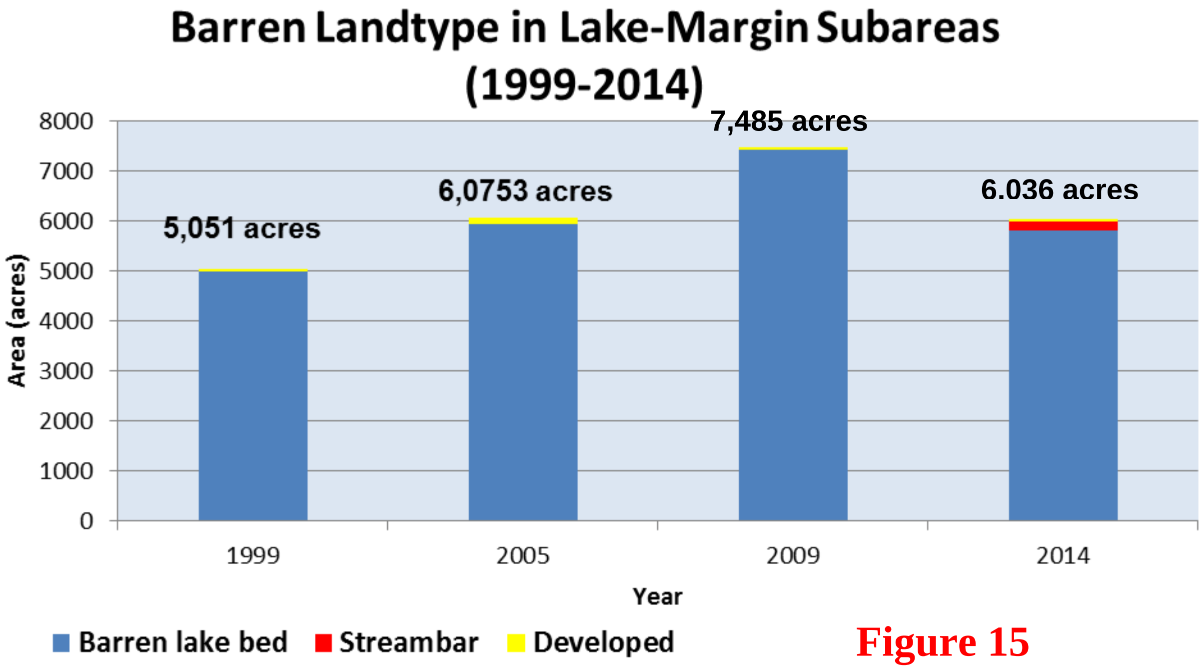
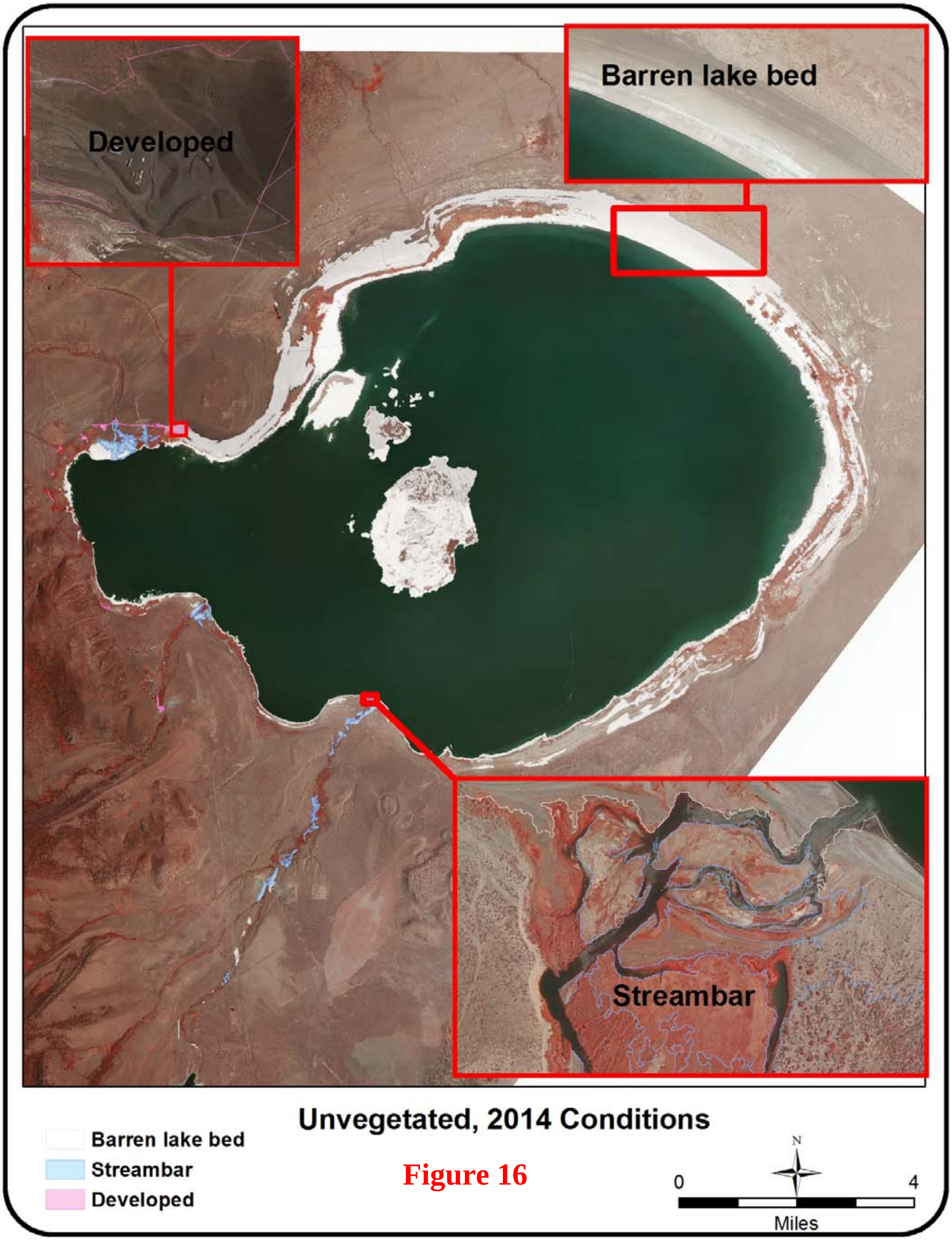


Figure 15

Unvegetated: Mostly barren lake bed, but also includes streambars near the mouths of streams. Unvegetated area increased between 1999 and 2009, mostly in response to declining lake elevation exposing barren lake bed. Prior to 2014, unvegetated areas included large areas of rabbitbrush scrub. The 2014 decline in unvegetated is mostly partly a response to delineating 1,913 acres of rabbitbrush scrub on the lake bed.

Man Made: Includes parking areas, some roads, and a mined area. The area of cultural features ranged from 126 acres in 2005 to 53 acres in 2014



Unvegetated, 2014 Conditions

Figure 16

3.2 Tributary Subareas

Two tributary subareas (Rush Creek and Lee Vining Creek; Figure 2) were mapped in 2009 and 2014. Prominent landtypes are Great Basin scrub, riparian shrub, riparian woodland, and unvegetated (streambar). Minor differences between 2014 and 2009 areas may be a result of map errors.

Table 3. Landtype for tributary subareas, 2009 and 2014.

Landtype	2009		2014	
	(acres)	(%)	(acres)	(%)
Freshwater stream	13	1	27	2
Alkaline wet meadow	0	0	22	2
Dry meadow/forb	39	4	1	0
Riparian shrub	186	17	207	19
Riparian woodland	55	5	63	6
Great Basin scrub	774	69	725	65
Unvegetated (streambar)	8	1	67	6
Man-made	42	4	5	0
TOTAL	**1117**	**100**	**1117**	**100**

3.3 Island Subarea

The island subarea (Figure 2) was mapped in 1999 and 2014. With declining lake elevation, the total area of island increased 331 acres. Principal landtypes are unvegetated barren lakebed and Great Basin scrub (Table 4).

Table 4. Landtype for island subarea, 1999 and 2014.

Landtype	1999		2014	
	(acres)	(%)	(acres)	(%)
Marsh	2	0	0	0
Alkaline wet meadow	0	0	10	0
Dry meadow/forb	7	0	75	3
Riparian shrub	0	0	59	2
Great Basin scrub	0	0	408	16
Unvegetated	2287	100	2074	79
Ephemeral brackish lagoon	0	0	0	0
Hypersaline lagoon	0	0	0	0
TOTAL	**2296**	**100**	**2627**	**100**

4.0 DISCUSSION

The purpose is to monitor changes in the extent of lake fringing wetland as a basis for evaluating waterfowl habitat. Landtype classes were originally selected to be: 1) compatible with previous vegetation mapping; 2) distinctive relative to waterfowl habitat values; and 3) distinguishable from imagery. Differences in the 1999, 2005, 2009, and 2014 distributions of landtypes between may be ascribed to biological/hydrologic changes and/or to mapping error. Mapping error is defined as the difference between the areas of landtype identified on the map and the true area of the same landtypes on the ground[8]. Two approaches to mapping have been applied:

- In 1999 and 2005, landtype boundaries were drawn (heads-up) on imagery viewed at moderate scales. Map parcels included small areas of contrasting landtypes and boundaries were just good approximations. Lake-margin subareas were divided into less than a thousand parcels. Mapping is likely accurate (parcels labeled with the right landtype) but somewhat imprecise in that parcels included a high degree of contrasting landtypes.

- In 2009 and 2014, spectral analysis of high-resolution, 4-band imagery was applied at the pixel scale (meter). Map boundaries are precise and every tiny area with contrasting spectral character was delineated. Lake-margin subareas were divided into many million parcels, most of which are noise. Differences in spectral character across the same landtype and similarities in spectral character for the different landtypes complicate interpretation of spectral classes. Mapping is precise, but relatively inaccurate in that a large percentage of the parcels were mis-identified. The spectral signature of some landtypes overlap and they are not easily distinguishable from imagery. Results of the 2009 supervised spectral analysis using ERDAS Imagine were not directly comparable to 2014 unsupervised spectral analysis using ArcMap Spatial Analyst.

Different approaches to mapping, technological advances, vagaries in landtype classes, and the views of different applicators all contribute to mapping error that is difficult to quantify. It appears that a significant faction of the differences in the extent of landtypes between 1999, 2005, 2009, and 2014 is a result of mapping error and not in response to biological/hydrologic changes. An exception is the extent of recently exposed shoreline resulting from the continued decline in Mono Lake water surface elevation. Also it seems there may be a general trend towards wetter conditions that may reflect a degree of eutrophication and accretion, especially in spring areas.

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[8] The inherent assumption here is that landtypes are precisely defined, which they are not.

APPENDIX A
LANDTYPE BY SUBAREA AND YEAR

Table A-1. Landtype by subarea and year.

Landtype	1999			2005			2009			2014		
	N	(acres)	(%)	N	(acres)	(%)	N	(acres)	(%)	N	(acres)	(%)
South tufa												
Marsh	1	2	1	4	3	1	40	2	1	11	3	1
Alkaline wet meadow	0	0	0	6	7	2	7	1	0	1	1	0
Dry meadow/forb	0	0	0	3	19	6	20	15	5	7	11	3
Riparian shrub	0	0	0	0	0	0	3	0	0	9	5	1
Great Basin scrub	7	246	82	10	221	71	120	128	41	10	261	79
Riparian woodland	0	0	0	0	0	0	0	0	0	12	36	11
Unvegetated	11	44	15	5	51	16	165	167	53	1	1	0
Man-made	3	6	2	2	10	3	0	0	0	0	0	0
Ria	0	0	0	0	0	0	0	0	0	0	0	0
Freshwater stream	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeral brackish lagoon	0	0	0	1	0	0	0	0	0	2	0	0
Hypersaline lagoon	0	0	0	0	0	0	0	0	0	0	0	0
Wet meadow	0	0	0	0	0	0	0	0	0	9	12	4
Freshwater pond	0	0	0	0	0	0	1	0	0	1	0	0
Mud flat	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	**22**	**299**	**100**	**31**	**311**	**100**	**356**	**313**	**100**	**63**	**331**	**100**
South shore lagoon												
Marsh	0	0	0	11	14	1	83	7	1	13	11	1
Alkaline wet meadow	9	8	1	12	71	6	169	64	5	42	46	4
Dry meadow/forb	18	240	20	12	116	9	422	88	7	4	0	0
Riparian shrub	2	3	0	1	0	0	2	1	0	22	8	1
Great Basin scrub	14	268	23	26	348	28	603	220	18	61	792	61
Riparian woodland	0	0	0	0	0	0	0	0	0	0	0	0
Unvegetated	19	627	54	21	679	55	223	859	69	28	354	27
Man-made	1	3	0	2	11	1	0	0	0	0	0	0
Ria	0	0	0	0	0	0	0	0	0	0	0	0
Freshwater stream	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeral brackish lagoon	20	24	2	7	2	0	1	1	0	38	3	0
Hypersaline lagoon	0	0	0	13	2	0	0	0	0	4	0	0
Wet meadow	0	0	0	5	0	0	0	0	0	42	78	6
Freshwater pond	0	0	0	0	0	0	8	5	0	2	4	0
Mud flat	0	0	0	0	0	0	0	0	0	3	1	0
TOTAL	**83**	**1172**	**100**	**110**	**1245**	**100**	**1511**	**1244**	**100**	**259**	**1298**	**100**

Table A-1. Landtype by subarea and year.

Landtype	1999			2005			2009			2014		
	N	(acres)	(%)	N	(acres)	(%)	N	(acres)	(%)	N	(acres)	(%)
Sammonn Spring												
Marsh	7	166	16	15	134	12	152	377	33	38	76	6
Alkaline wet meadow	10	179	17	7	223	20	214	115	10	25	34	3
Dry meadow/forb	13	267	26	8	183	16	60	51	4	0	0	0
Riparian shrub	1	2	0	1	18	2	0	0	0	6	1	0
Great Basin scrub	3	261	25	7	242	22	166	171	15	50	463	39
Riparian woodland	0	0	0	0	0	0	0	0	0	0	0	0
Unvegetated	45	151	15	37	312	28	244	415	37	33	172	14
Man-made	0	0	0	1	5	0	0	0	0	0	0	0
Ria	0	0	0	0	0	0	0	0	0	0	0	0
Freshwater stream	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeral brackish lagoon	13	9	1	1	0	0	6	1	0	20	2	0
Hypersaline lagoon	0	0	0	1	1	0	0	0	0	0	0	0
Wet meadow	0	0	0	0	0	0	0	0	0	21	449	37
Freshwater pond	20	1	0	1	1	0	3	0	0	36	2	0
Mud flat	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	**112**	**1036**	**100**	**79**	**1119**	**100**	**845**	**1130**	**100**	**229**	**1199**	**100**
Sammann Spring east												
Marsh	5	15	3	2	13	2	42	26	4	5	4	1
Alkaline wet meadow	2	106	20	1	129	19	94	121	20	55	41	6
Dry meadow/forb	9	121	22	5	108	16	68	34	6	0	0	0
Riparian shrub	0	0	0	0	0	0	0	0	0	0	0	0
Great Basin scrub	2	136	25	2	189	28	103	42	7	2	226	34
Riparian woodland	0	0	0	0	0	0	0	0	0	0	0	0
Unvegetated	15	160	30	10	233	35	116	397	64	30	257	39
Man-made	0	0	0	0	0	0	0	0	0	0	0	0
Ria	0	0	0	0	0	0	0	0	0	0	0	0
Freshwater stream	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeral brackish lagoon	5	3	1	0	0	0	0	0	0	2	0	0
Hypersaline lagoon	0	0	0	0	0	0	2	0	0	1	0	0
Wet meadow	0	0	0	0	0	0	0	0	0	1	135	20
Freshwater pond	0	0	0	0	0	0	0	0	0	0	0	0
Mud flat	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	**38**	**541**	**100**	**20**	**672**	**100**	**425**	**621**	**100**	**96**	**664**	**100**

Table A-1. Landtype by subarea and year.

Landtype	1999			2005			2009			2014		
	N	(acres)	(%)	N	(acres)	(%)	N	(acres)	(%)	N	(acres)	(%)
Warm Spring												
Marsh	11	66	5	8	86	6	152	83	6	10	79	5
Alkaline wet meadow	20	233	18	12	174	12	190	315	22	109	181	11
Dry meadow/forb	23	394	31	14	365	26	119	111	8	0	0	0
Riparian shrub	0	0	0	0	0	0	0	0	0	3	0	0
Great Basin scrub	4	360	28	2	362	26	498	397	28	10	430	26
Riparian woodland	0	0	0	0	0	0	0	0	0	0	0	0
Unvegetated	81	192	15	60	413	29	439	532	37	60	719	44
Man-made	0	0	0	0	0	0	0	0	0	0	0	0
Ria	0	0	0	0	0	0	0	0	0	0	0	0
Freshwater stream	0	0	0	0	0	0	0	0	0	1	0	0
Ephemeral brackish lagoon	14	30	2	2	5	0	5	3	0	21	7	0
Hypersaline lagoon	0	0	0	0	0	0	0	0	0	2	0	0
Wet meadow	0	0	0	0	0	0	0	0	0	11	212	13
Freshwater pond	6	0	0	4	0	0	0	0	0	2	0	0
Mud flat	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	**159**	**1274**	**100**	**102**	**1406**	**100**	**1403**	**1442**	**100**	**229**	**1629**	**100**
Northeast shore												
Marsh	1	1	0	1	2	0	115	10	0	9	12	0
Alkaline wet meadow	5	20	1	6	32	1	139	90	4	113	168	7
Dry meadow/forb	24	190	8	11	210	9	59	113	5	0	0	0
Riparian shrub	0	0	0	0	0	0	0	0	0	2	0	0
Great Basin scrub	2	205	9	1	208	9	536	248	10	30	375	15
Riparian woodland	0	0	0	0	0	0	0	0	0	0	0	0
Unvegetated	8	1830	77	3	1970	81	209	1946	81	16	1909	77
Man-made	0	0	0	0	0	0	0	0	0	0	0	0
Ria	0	0	0	0	0	0	0	0	0	0	0	0
Freshwater stream	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeral brackish lagoon	2	22	1	0	0	0	2	1	0	6	1	0
Hypersaline lagoon	6	105	4	7	6	0	0	0	0	0	0	0
Wet meadow	0	0	0	0	0	0	0	0	0	10	27	1
Freshwater pond	0	0	0	0	0	0	0	0	0	0	0	0
Mud flat	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	**48**	**2373**	**100**	**29**	**2430**	**100**	**1060**	**2407**	**100**	**186**	**2492**	**100**

Table A-1. Landtype by subarea and year.

Landtype	1999			2005			2009			2014		
	N	(acres)	(%)	N	(acres)	(%)	N	(acres)	(%)	N	(acres)	(%)
Bridgeport Creek Delta												
Marsh	4	9	1	1	2	0	273	40	3	23	8	1
Alkaline wet meadow	0	0	0	1	260	19	105	174	13	29	277	19
Dry meadow/forb	9	292	23	6	123	9	348	197	15	6	14	1
Riparian shrub	0	0	0	0	0	0	0	0	0	27	5	0
Great Basin scrub	7	277	22	7	283	21	285	342	25	83	364	25
Riparian woodland	0	0	0	0	0	0	0	0	0	0	0	0
Unvegetated	27	651	52	24	677	50	182	599	44	10	724	50
Man-made	0	0	0	0	0	0	0	0	0	0	0	0
Ria	0	0	0	0	0	0	0	0	0	9	2	0
Freshwater stream	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeral brackish lagoon	9	12	1	0	0	0	0	0	0	2	0	0
Hypersaline lagoon	4	2	0	1	2	0	0	0	0	2	0	0
Wet meadow	0	0	0	0	0	0	0	0	0	36	65	4
Freshwater pond	1	0	0	0	0	0	0	0	0	1	0	0
Mud flat	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	**61**	**1243**	**100**	**40**	**1347**	**100**	**1193**	**1352**	**100**	**228**	**1458**	**100**
Dechambeau Embayment												
Marsh	13	25	2	15	81	5	271	144	9	114	48	3
Alkaline wet meadow	0	0	0	3	224	15	80	143	9	20	146	9
Dry meadow/forb	5	227	16	2	108	7	397	97	6	2	8	0
Riparian shrub	3	7	0	1	0	0	0	0	0	62	8	0
Great Basin scrub	7	650	46	18	557	36	440	397	26	39	655	40
Riparian woodland	0	0	0	0	0	0	0	0	0	0	0	0
Unvegetated	24	482	34	11	545	36	313	769	49	31	635	39
Man-made	0	0	0	1	9	1	0	0	0	0	0	0
Ria	0	0	0	0	0	0	0	0	0	2	2	0
Freshwater stream	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeral brackish lagoon	10	1	0	1	0	0	0	0	0	1	1	0
Hypersaline lagoon	0	0	0	1	0	0	0	0	0	0	0	0
Wet meadow	2	18	1	0	0	0	0	0	0	4	124	8
Freshwater pond	8	7	1	5	11	1	8	4	0	10	5	0
Mud flat	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	**72**	**1418**	**100**	**58**	**1536**	**100**	**1509**	**1555**	**100**	**285**	**1632**	**100**

Table A-1. Landtype by subarea and year.

Landtype	1999			2005			2009			2014		
	N	(acres)	(%)	N	(acres)	(%)	N	(acres)	(%)	N	(acres)	(%)
Black Point												
Marsh	2	1	0	2	6	1	50	14	2	15	3	0
Alkaline wet meadow	7	10	1	3	82	10	13	42	5	15	41	4
Dry meadow/forb	13	32	4	1	1	0	130	15	2	8	15	1
Riparian shrub	0	0	0	0	0	0	0	0	0	22	4	0
Great Basin scrub	2	145	20	6	91	11	170	41	5	12	129	13
Riparian woodland	0	0	0	0	0	0	0	0	0	0	0	0
Unvegetated	13	543	73	2	645	78	81	773	87	14	759	75
Man-made	0	0	0	3	2	0	1	1	0	1	3	0
Ria	0	0	0	0	0	0	0	0	0	47	31	3
Freshwater stream	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeral brackish lagoon	15	5	1	2	1	0	0	0	0	0	0	0
Hypersaline lagoon	4	4	0	0	0	0	0	0	0	4	0	0
Wet meadow	0	0	0	0	0	0	0	0	0	1	29	3
Freshwater pond	1	0	0	1	0	0	2	0	0	0	0	0
Mud flat	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	**57**	**740**	**100**	**20**	**829**	**100**	**447**	**887**	**100**	**139**	**1014**	**100**
Mill/Wilson Creek Deltas												
Marsh	0	0	0	9	12	2	34	11	2	1	0	0
Alkaline wet meadow	1	0	0	3	19	4	56	8	2	14	8	2
Dry meadow/forb	2	24	5	4	24	5	74	29	6	4	7	1
Riparian shrub	16	70	15	13	11	2	28	11	2	102	80	16
Great Basin scrub	12	193	40	19	212	43	83	231	46	22	136	27
Riparian woodland	3	2	0	2	5	1	16	4	1	6	1	0
Unvegetated	30	135	28	16	130	26	98	148	29	42	180	35
Man-made	4	30	6	3	42	9	4	39	8	2	44	9
Ria	0	0	0	0	0	0	1	0	0	6	2	0
Freshwater stream	5	3	1	2	4	1	28	2	0	29	3	0
Ephemeral brackish lagoon	8	2	0	1	0	0	0	0	0	0	0	0
Hypersaline lagoon	0	0	0	1	0	0	0	0	0	0	0	0
Wet meadow	6	21	4	6	35	7	38	22	4	7	47	9
Freshwater pond	1	0	0	0	0	0	0	0	0	7	1	0
Mud flat	0	0	0	0	0	0	0	0	0	6	5	1
TOTAL	**88**	**480**	**100**	**79**	**493**	**100**	**460**	**505**	**100**	**248**	**513**	**100**

Table A-1. Landtype by subarea and year.

Landtype	1999			2005			2009			2014		
	N	(acres)	(%)	N	(acres)	(%)	N	(acres)	(%)	N	(acres)	(%)
Dechambeau Creek Delta												
Marsh	0	0	0	1	4	2	37	11	5	12	5	2
Alkaline wet meadow	0	0	0	0	0	0	2	0	0	10	31	14
Dry meadow/forb	5	28	15	5	50	25	68	51	25	1	2	1
Riparian shrub	7	62	32	6	47	23	51	52	26	48	73	34
Great Basin scrub	3	41	22	4	40	20	64	35	17	11	53	25
Riparian woodland	1	1	1	0	0	0	0	0	0	14	4	2
Unvegetated	3	8	4	2	9	5	46	17	8	15	15	7
Man-made	4	7	3	4	22	11	3	20	10	7	4	2
Ria	0	0	0	0	0	0	4	0	0	1	1	0
Freshwater stream	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeral brackish lagoon	1	0	0	0	0	0	0	0	0	0	0	0
Hypersaline lagoon	0	0	0	0	0	0	0	0	0	0	0	0
Wet meadow	2	44	23	1	29	15	9	18	9	7	23	11
Freshwater pond	0	0	0	0	0	0	0	0	0	2	0	0
Mud flat	0	0	0	0	0	0	0	0	0	6	4	2
TOTAL	**26**	**191**	**100**	**23**	**201**	**100**	**284**	**203**	**100**	**134**	**214**	**100**
West shore/Lee Vining Delta												
Marsh	4	11	2	25	39	6	65	38	5	21	6	1
Alkaline wet meadow	7	24	4	9	40	6	82	9	1	10	20	3
Dry meadow/forb	11	101	17	7	31	5	77	79	11	21	71	10
Riparian shrub	20	79	13	14	62	10	93	64	9	115	91	13
Great Basin scrub	12	317	53	22	303	48	258	167	24	47	272	40
Riparian woodland	2	5	1	3	17	3	27	21	3	15	22	3
Unvegetated	27	52	9	31	123	20	163	306	44	113	105	15
Man-made	4	7	1	6	12	2	9	8	1	2	2	0
Ria	2	1	0	0	0	0	1	0	0	7	2	0
Freshwater stream	1	2	0	1	2	0	7	2	0	15	3	0
Ephemeral brackish lagoon	0	0	0	0	0	0	0	0	0	0	0	0
Hypersaline lagoon	0	0	0	0	0	0	0	0	0	3	0	0
Wet meadow	0	0	0	0	0	0	0	0	0	14	84	12
Freshwater pond	0	0	0	0	0	0	0	0	0	0	0	0
Mud flat	0	0	0	0	0	0	0	0	0	7	5	1
TOTAL	**90**	**598**	**100**	**118**	**628**	**100**	**782**	**695**	**100**	**390**	**681**	**100**

Table A-1. Landtype by subarea and year.

Landtype	1999			2005			2009			2014		
	N	(acres)	(%)	N	(acres)	(%)	N	(acres)	(%)	N	(acres)	(%)
Lee Vining tufa												
Marsh	1	4	4	2	5	4	12	3	2	0	0	0
Alkaline wet meadow	1	1	1	0	0	0	1	0	0	1	0	0
Dry meadow/forb	3	5	5	3	9	8	17	9	8	3	22	18
Riparian shrub	8	17	15	10	16	14	40	17	15	43	23	19
Great Basin scrub	2	79	71	1	78	69	6	75	64	3	52	43
Riparian woodland	0	0	0	0	0	0	0	0	0	0	0	0
Unvegetated	5	5	4	3	5	4	46	13	11	6	8	7
Man-made	0	0	0	1	2	1	0	0	0	0	0	0
Ria	0	0	0	0	0	0	0	0	0	0	0	0
Freshwater stream	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeral brackish lagoon	0	0	0	0	0	0	0	0	0	0	0	0
Hypersaline lagoon	0	0	0	0	0	0	0	0	0	1	0	0
Wet meadow	0	0	0	0	0	0	0	0	0	2	15	13
Freshwater pond	0	0	0	0	0	0	0	0	0	0	0	0
Mud flat	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	**20**	**112**	**100**	**20**	**113**	**100**	**122**	**117**	**100**	**59**	**122**	**100**
Ranch Cove												
Marsh	0	0	0	1	0	0	5	0	0	0	0	0
Alkaline wet meadow	0	0	0	3	14	7	27	8	4	7	3	1
Dry meadow/forb	0	0	0	0	0	0	20	3	2	3	3	1
Riparian shrub	9	49	24	14	22	10	47	27	13	78	50	23
Great Basin scrub	6	124	60	2	148	71	41	123	58	13	139	64
Riparian woodland	0	0	0	0	0	0	0	0	0	1	0	0
Unvegetated	4	31	15	10	25	12	53	49	23	8	23	11
Man-made	0	0	0	3	1	0	0	0	0	0	0	0
Ria	0	0	0	0	0	0	0	0	0	0	0	0
Freshwater stream	0	0	0	0	0	0	1	0	0	0	0	0
Ephemeral brackish lagoon	2	1	0	0	0	0	0	0	0	0	0	0
Hypersaline lagoon	0	0	0	0	0	0	0	0	0	0	0	0
Wet meadow	0	0	0	0	0	0	0	0	0	0	0	0
Freshwater pond	0	0	0	0	0	0	0	0	0	0	0	0
Mud flat	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	**21**	**205**	**100**	**33**	**209**	**100**	**194**	**212**	**100**	**110**	**218**	**100**

Table A-1. Landtype by subarea and year.

Landtype	1999			2005			2009			2014		
	N	(acres)	(%)	N	(acres)	(%)	N	(acres)	(%)	N	(acres)	(%)
Rush Creek Delta												
Marsh	0	0	0	5	8	1	17	3	0	8	2	0
Alkaline wet meadow	0	0	0	5	18	3	32	5	1	4	3	0
Dry meadow/forb	0	0	0	4	9	1	98	18	2	0	0	0
Riparian shrub	23	45	7	2	29	4	83	43	5	75	34	5
Great Basin scrub	12	517	79	21	451	68	286	281	36	49	558	81
Riparian woodland	0	0	0	0	0	0	8	1	0	12	1	0
Unvegetated	27	81	12	7	131	20	163	424	54	27	85	12
Man-made	3	5	1	1	10	1	3	3	0	0	0	0
Ria	1	2	0	1	1	0	2	1	0	0	0	0
Freshwater stream	2	6	1	4	7	1	12	9	1	10	7	1
Ephemeral brackish lagoon	1	0	0	2	0	0	0	0	0	0	0	0
Hypersaline lagoon	0	0	0	0	0	0	0	0	0	0	0	0
Wet meadow	0	0	0	0	0	0	0	0	0	5	1	0
Freshwater pond	0	0	0	0	0	0	1	0	0	3	0	0
Mud flat	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	**69**	**657**	**100**	**52**	**664**	**100**	**705**	**787**	**100**	**193**	**691**	**100**
ALL LAKE MARGIN SUBAREAS												
Marsh	49	300	2	102	409	3	1348	766	6	280	256	2
Alkaline wet meadow	62	582	5	71	1293	10	1211	1095	8	455	1000	7
Dry meadow/forb	135	1922	16	85	1355	10	1977	912	7	59	152	1
Riparian shrub	89	334	3	62	204	2	347	215	2	614	382	3
Great Basin scrub	95	3819	31	148	3733	28	3659	2898	22	442	4905	35
Riparian woodland	6	8	0	5	21	0	51	26	0	60	64	0
Unvegetated	339	4992	40	242	5949	45	2541	7414	55	434	5949	42
Man-made	19	58	0	27	126	1	20	71	1	12	53	0
Ria	3	3	0	1	1	0	8	2	0	72	39	0
Freshwater stream	8	10	0	7	13	0	48	14	0	55	12	0
Ephemeral brackish lagoon	100	109	1	17	9	0	14	6	0	92	15	0
Hypersaline lagoon	14	111	1	24	12	0	2	0	0	17	1	0
Wet meadow	10	83	1	12	64	0	47	40	0	170	1301	9
Freshwater pond	37	9	0	11	12	0	23	10	0	64	13	0
Mud flat	0	0	0	0	0	0	0	0	0	22	15	0
TOTAL	966	12340	100	814	13202	100	11296	13469	100	2848	14157	100

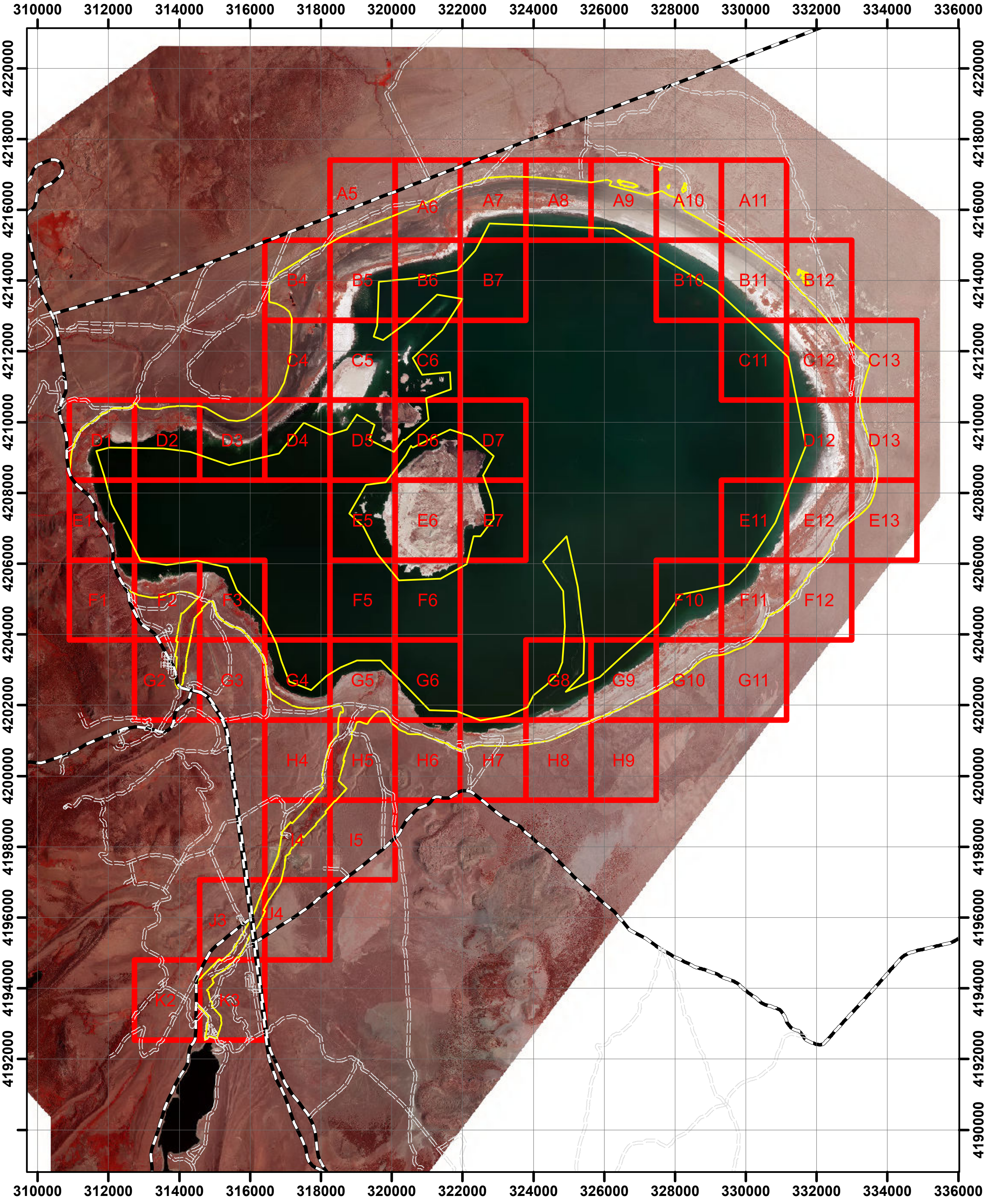
Table A-1. Landtype by subarea and year.

Landtype	1999			2005			2009			2014		
	N	(acres)	(%)	N	(acres)	(%)	N	(acres)	(%)	N	(acres)	(%)
Rush Creek												
Marsh	0	0	0	0	0	0	0	0	0	0	0	0
Alkaline wet meadow	0	0	0	0	0	0	0	0	0	22	22	2
Dry meadow/forb	0	0	0	0	0	0	346	39	4	0	0	0
Riparian shrub	0	0	0	0	0	0	207	156	17	219	187	20
Great Basin scrub	0	0	0	0	0	0	167	644	71	52	607	66
Riparian woodland	0	0	0	0	0	0	137	21	2	53	10	1
Unvegetated	0	0	0	0	0	0	49	5	1	38	67	7
Man-made	0	0	0	0	0	0	30	31	3	0	0	0
Ria	0	0	0	0	0	0	0	0	0	0	0	0
Freshwater stream	0	0	0	0	0	0	83	11	1	58	22	2
Ephemeral brackish lagoon	0	0	0	0	0	0	0	0	0	0	0	0
Hypersaline lagoon	0	0	0	0	0	0	0	0	0	0	0	0
Wet meadow	0	0	0	0	0	0	0	0	0	0	0	0
Freshwater pond	0	0	0	0	0	0	0	0	0	0	0	0
Mud flat	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	**0**	**0**	**0**	**0**	**0**	**0**	**1019**	**906**	**100**	**442**	**915**	**100**
Lee Vining Creek												
Marsh	0	0	0	0	0	0	0	0	0	0	0	0
Alkaline wet meadow	0	0	0	0	0	0	0	0	0	0	0	0
Dry meadow/forb	0	0	0	0	0	0	10	1	0	1	1	0
Riparian shrub	0	0	0	0	0	0	27	29	14	36	20	9
Great Basin scrub	0	0	0	0	0	0	26	130	62	11	128	60
Riparian woodland	0	0	0	0	0	0	44	35	17	29	53	25
Unvegetated	0	0	0	0	0	0	30	2	1	2	0	0
Man-made	0	0	0	0	0	0	5	11	5	2	5	2
Ria	0	0	0	0	0	0	0	0	0	0	0	0
Freshwater stream	0	0	0	0	0	0	14	2	1	22	5	2
Ephemeral brackish lagoon	0	0	0	0	0	0	0	0	0	0	0	0
Hypersaline lagoon	0	0	0	0	0	0	0	0	0	0	0	0
Wet meadow	0	0	0	0	0	0	0	0	0	0	0	0
Freshwater pond	0	0	0	0	0	0	0	0	0	1	0	0
Mud flat	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	**0**	**0**	**0**	**0**	**0**	**0**	**156**	**210**	**100**	**104**	**212**	**100**

Table A-1. Landtype by subarea and year.

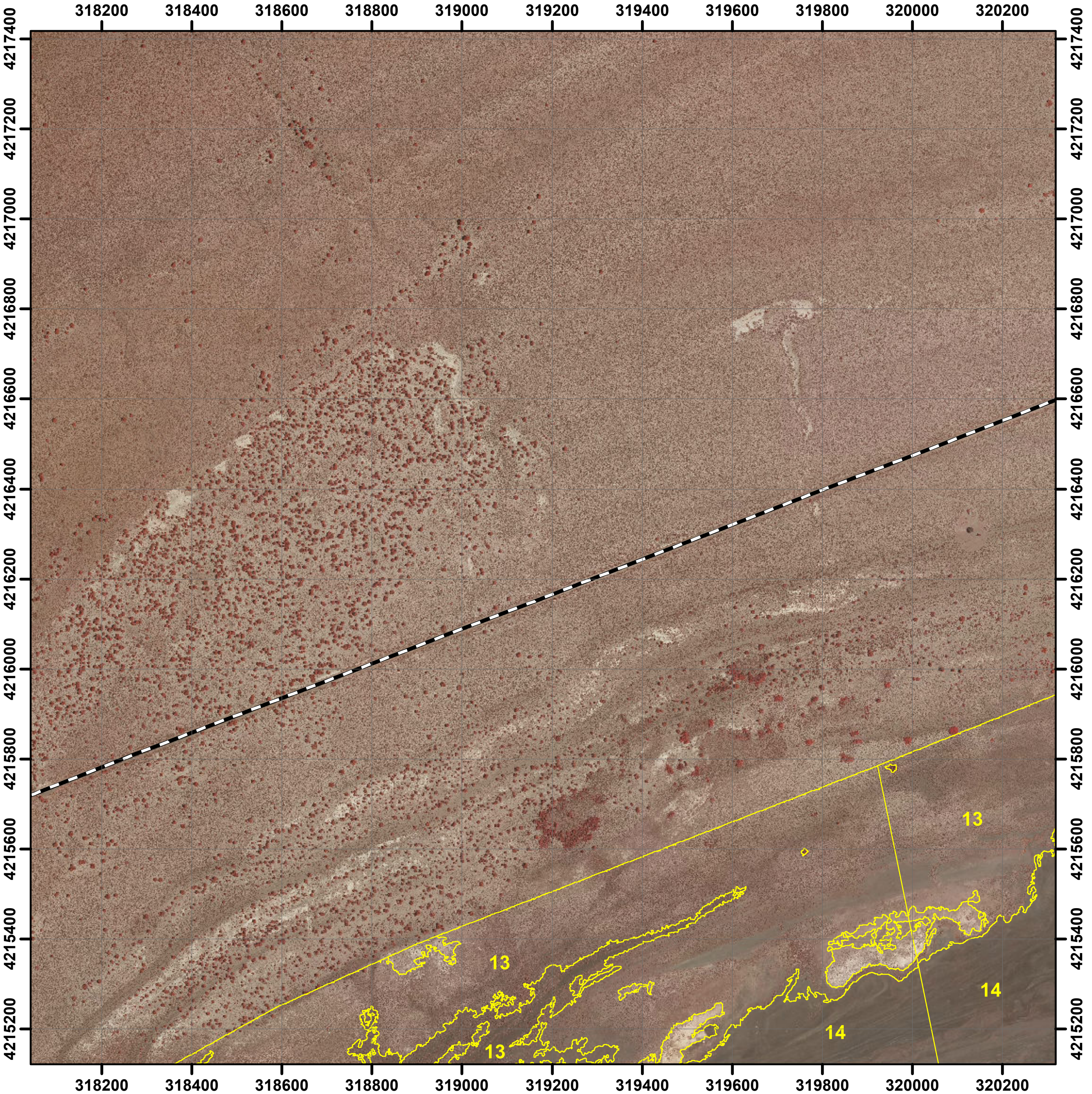
Landtype	1999			2005			2009			2014		
	N	(acres)	(%)	N	(acres)	(%)	N	(acres)	(%)	N	(acres)	(%)
Islands												
Marsh	2	2	0	0	0	0	0	0	0	0	0	0
Alkaline wet meadow	0	0	0	0	0	0	0	0	0	10	10	0
Dry meadow/forb	3	7	0	0	0	0	0	0	0	2	75	3
Riparian shrub	0	0	0	0	0	0	0	0	0	121	59	2
Great Basin scrub	0	0	0	0	0	0	0	0	0	241	408	16
Riparian woodland	0	0	0	0	0	0	0	0	0	0	0	0
Unvegetated	3	2287	100	0	0	0	0	0	0	139	2074	79
Man-made	0	0	0	0	0	0	0	0	0	0	0	0
Ria	0	0	0	0	0	0	0	0	0	0	0	0
Freshwater stream	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeral brackish lagoon	0	0	0	0	0	0	0	0	0	1	0	0
Hypersaline lagoon	0	0	0	0	0	0	0	0	0	4	0	0
Wet meadow	0	0	0	0	0	0	0	0	0	0	0	0
Freshwater pond	0	0	0	0	0	0	0	0	0	0	0	0
Mud flat	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	**8**	**2296**	**100**	**0**	**0**	**0**	**0**	**0**	**0**	**518**	**2627**	**100**
ALL SUBAREAS												
Marsh	51	302	2	102	409	3	1348	766	5	280	256	1
Alkaline wet meadow	62	582	4	71	1293	10	1211	1095	8	487	1031	6
Dry meadow/forb	138	1929	13	85	1355	10	2333	951	7	62	228	1
Riparian shrub	91	334	2	62	204	2	581	401	3	990	649	4
Great Basin scrub	97	3819	26	148	3733	28	3852	3672	25	746	6047	34
Riparian woodland	6	8	0	5	21	0	232	81	1	142	127	1
Unvegetated	342	7279	50	242	5949	45	2620	7421	51	613	8090	45
Man-made	19	58	0	27	126	1	55	113	1	14	58	0
Ria	3	3	0	1	1	0	8	2	0	72	39	0
Freshwater stream	10	10	0	7	13	0	145	26	0	135	39	0
Ephemeral brackish lagoon	100	109	1	17	9	0	14	6	0	93	16	0
Hypersaline lagoon	14	111	1	24	12	0	2	0	0	21	1	0
Wet meadow	10	83	1	12	64	0	47	40	0	170	1301	7
Freshwater pond	37	9	0	11	12	0	23	10	0	65	13	0
Mud flat	0	0	0	0	0	0	0	0	0	22	15	0
TOTAL	**980**	**14636**	**100**	**814**	**13202**	**100**	**12471**	**14585**	**100**	**3912**	**17910**	**100**

APPENDIX B
2014 LANDTYPE MAPPING



Mono Fringe Vegetation Mapping, 2014 Conditions

Map Index



Mono Lake Landtype, 2014 Conditions

Map A5

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
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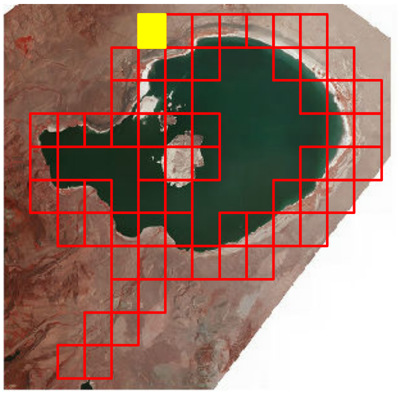
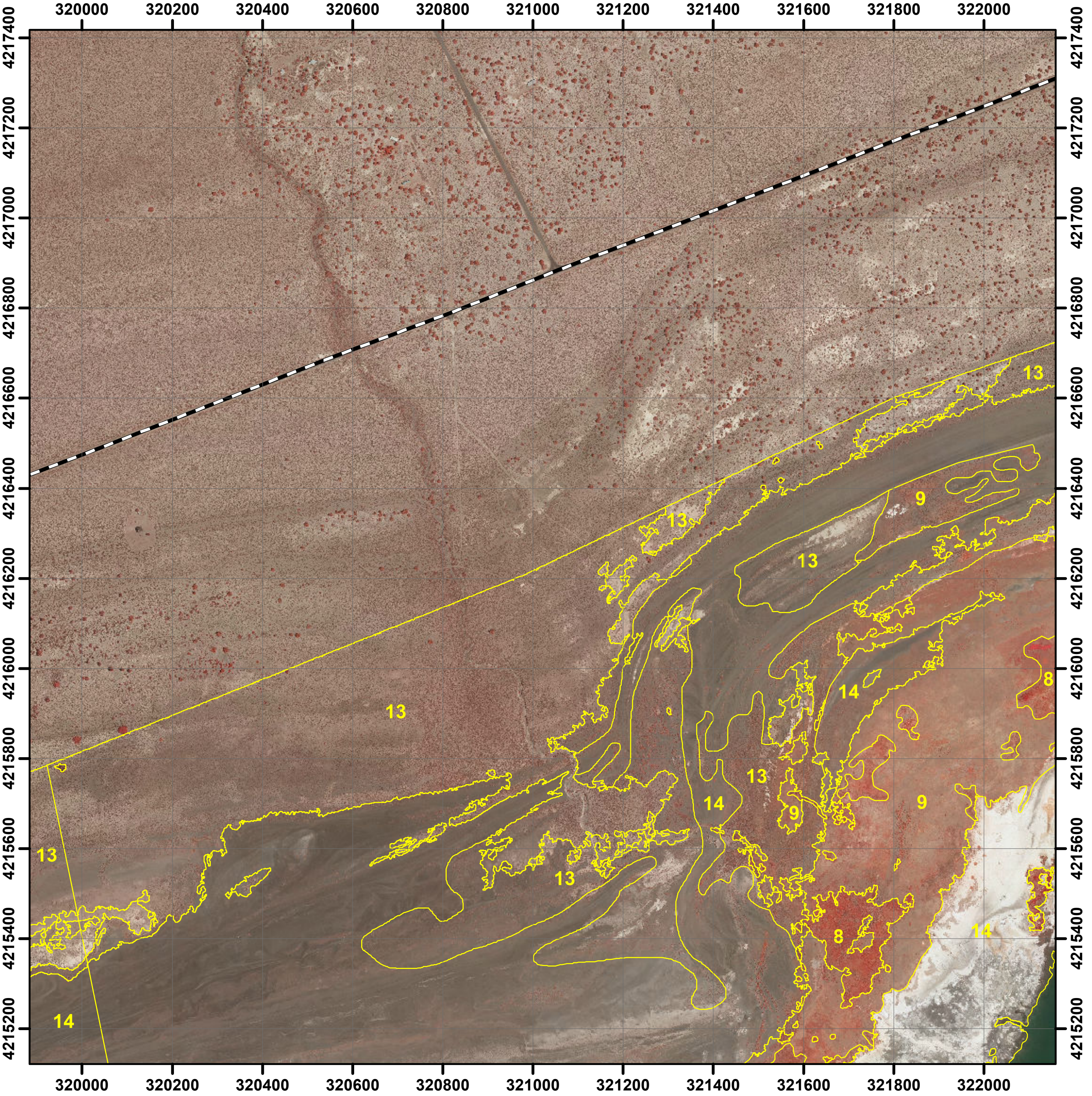
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made
● Photopoint

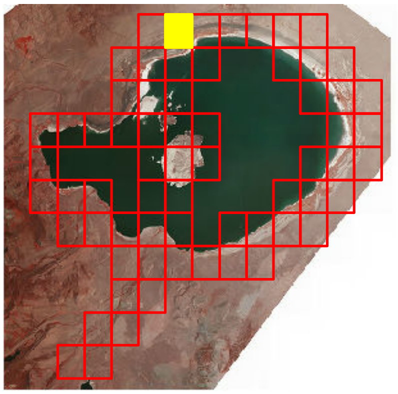


Note: Great Basin scrub is the combination of upland scrub, rabbitbrush, eolian, and pinyon woodland landtypes delineated in 2014; dry meadow/forb is rabbitbrush/meadow delineated in 2014; unvegetated is the combined area of barren lake bed and streambar delineated in 2014. Photopoints are linked to photographs in APPENDIX C.



Mono Lake Landtype, 2014 Conditions

Map A6



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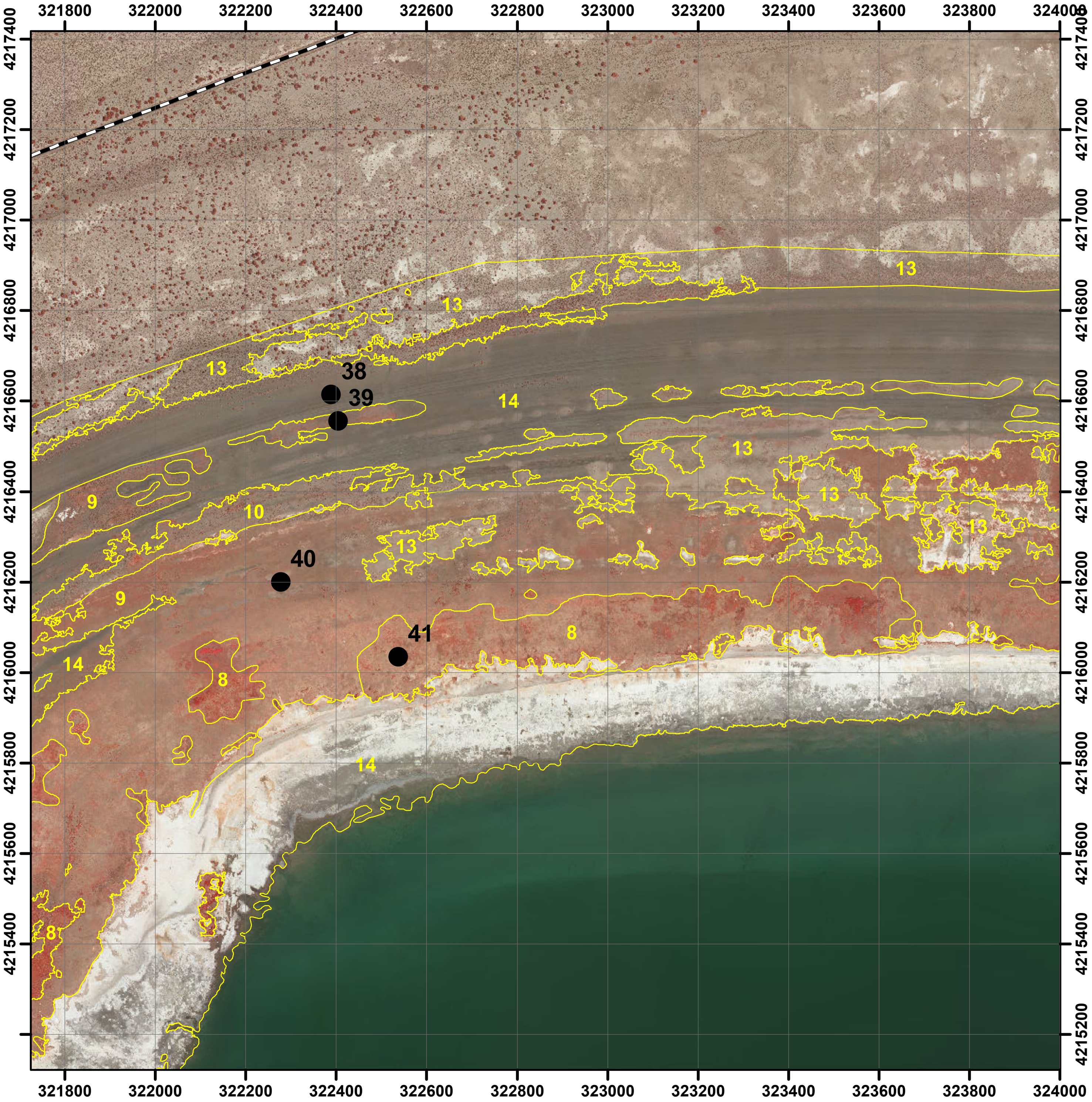
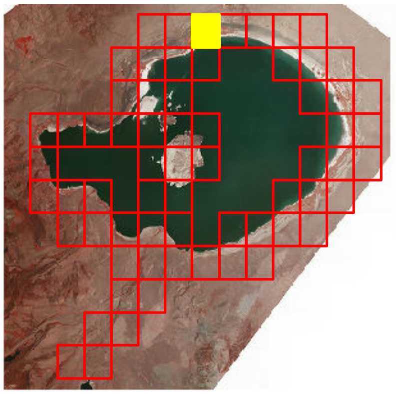


Mono Lake Landtype, 2014 Conditions

Map A7



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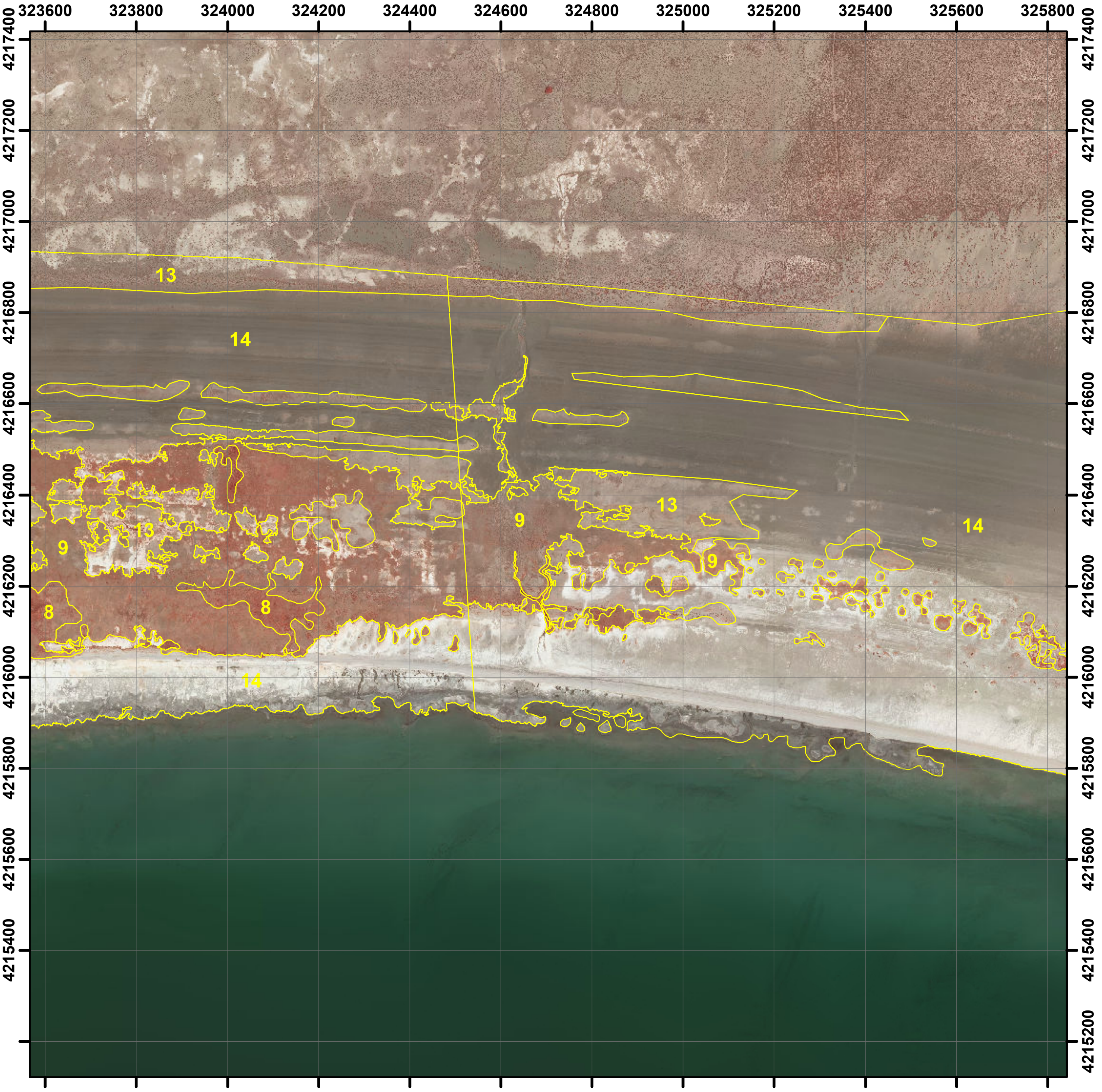
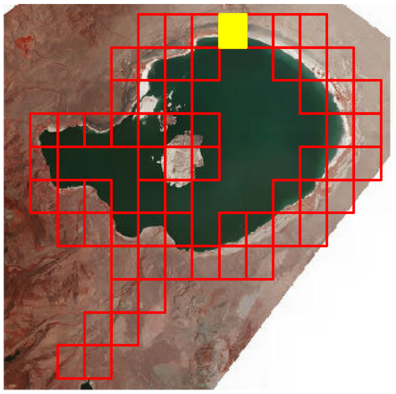


Mono Lake Landtype, 2014 Conditions

Map A8

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow

9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made
● Photopoint



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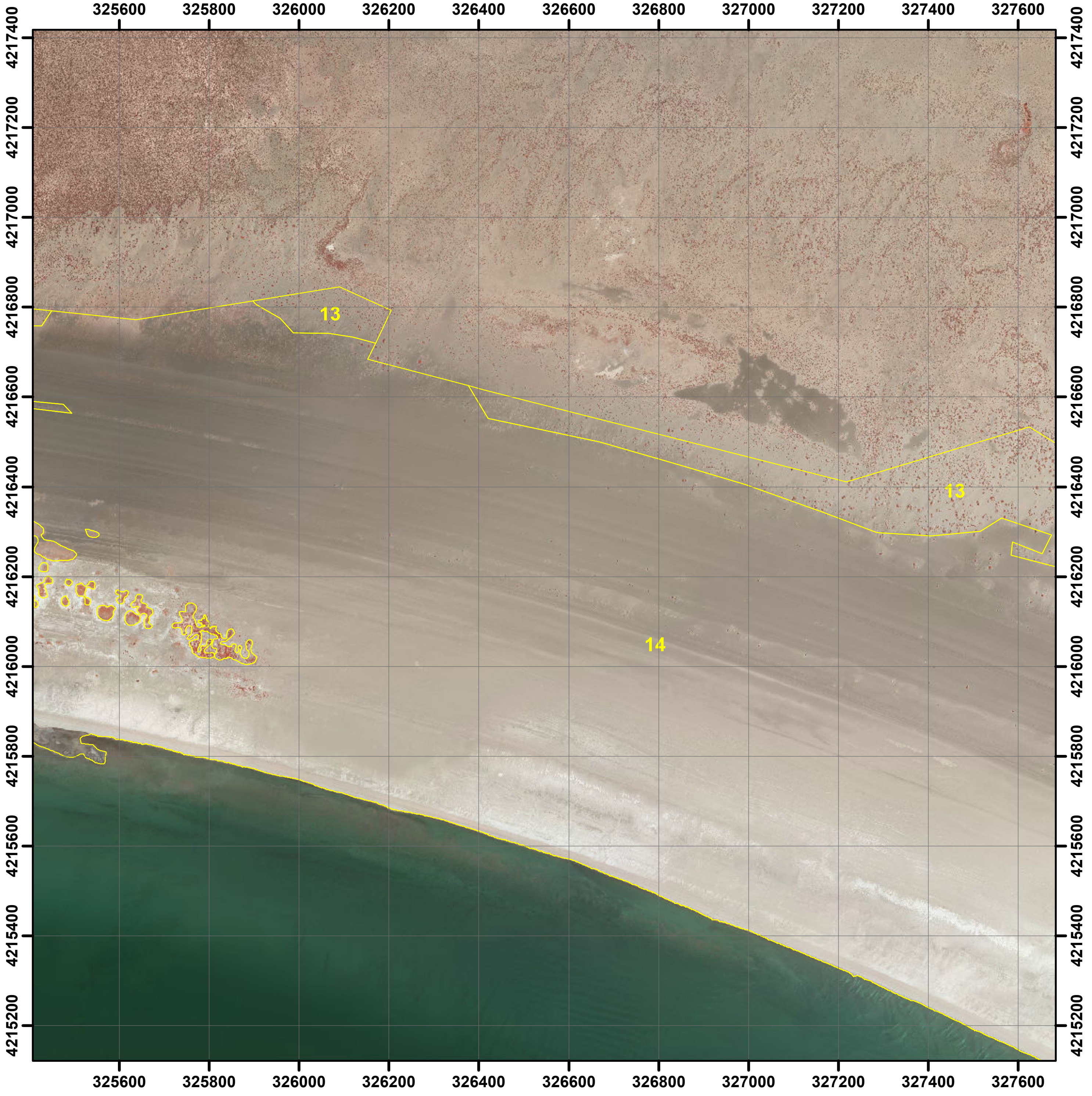
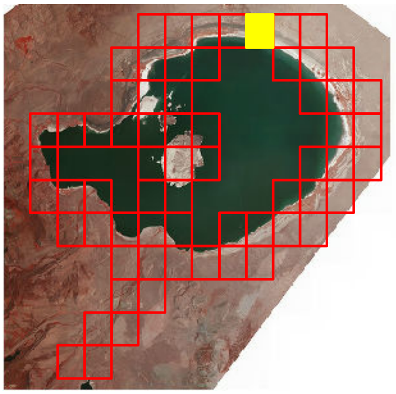


Mono Lake Landtype, 2014 Conditions

Map A9



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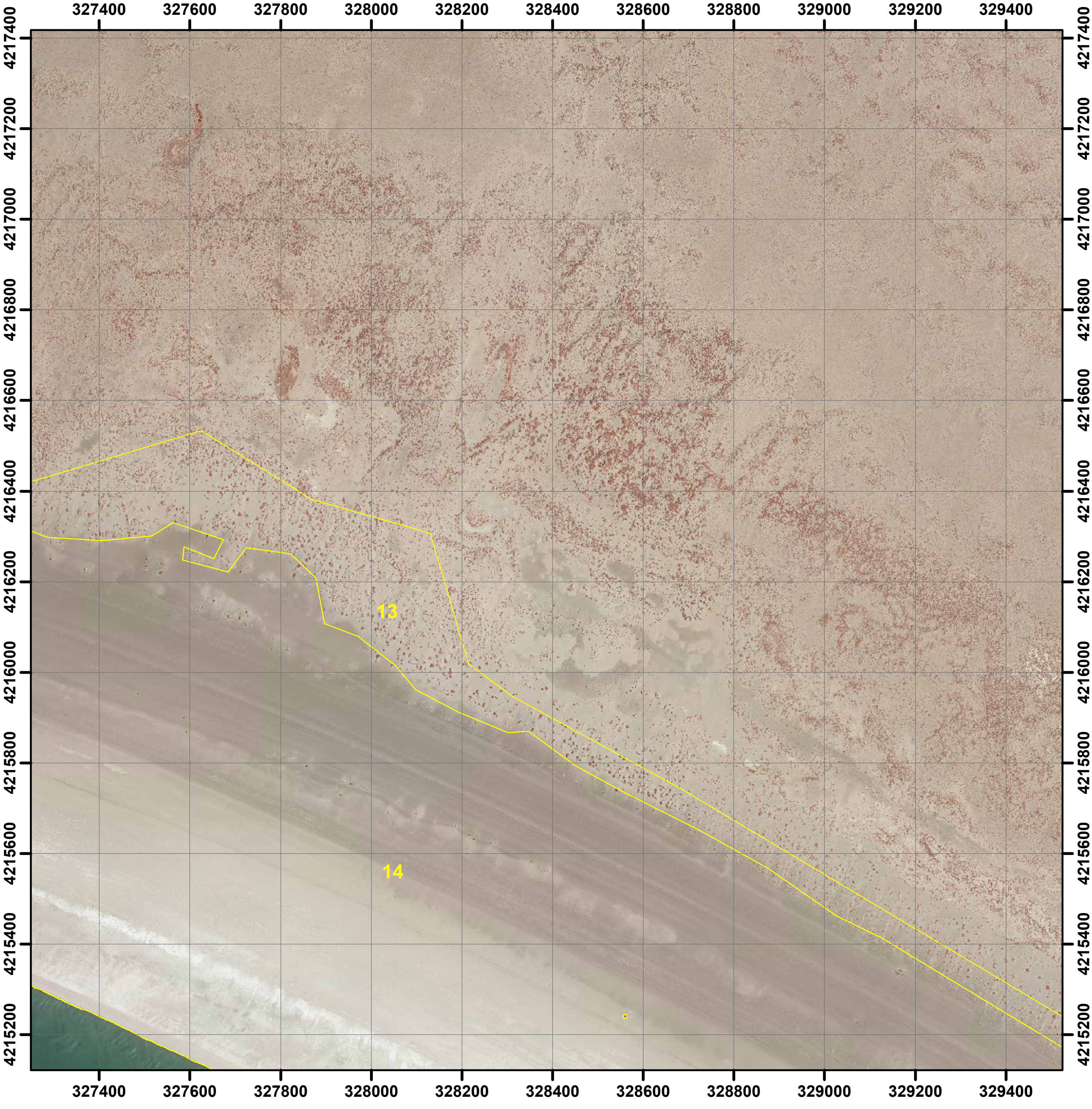
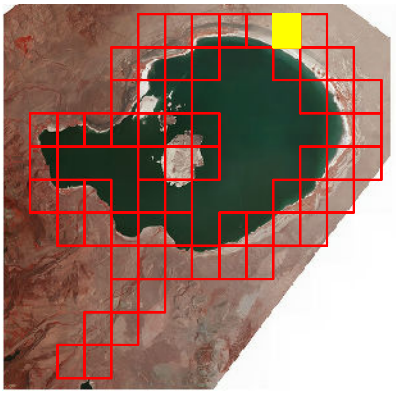


Mono Lake Landtype, 2014 Conditions
Map A10



1 = Freshwater stream
2 = Freshwater pond
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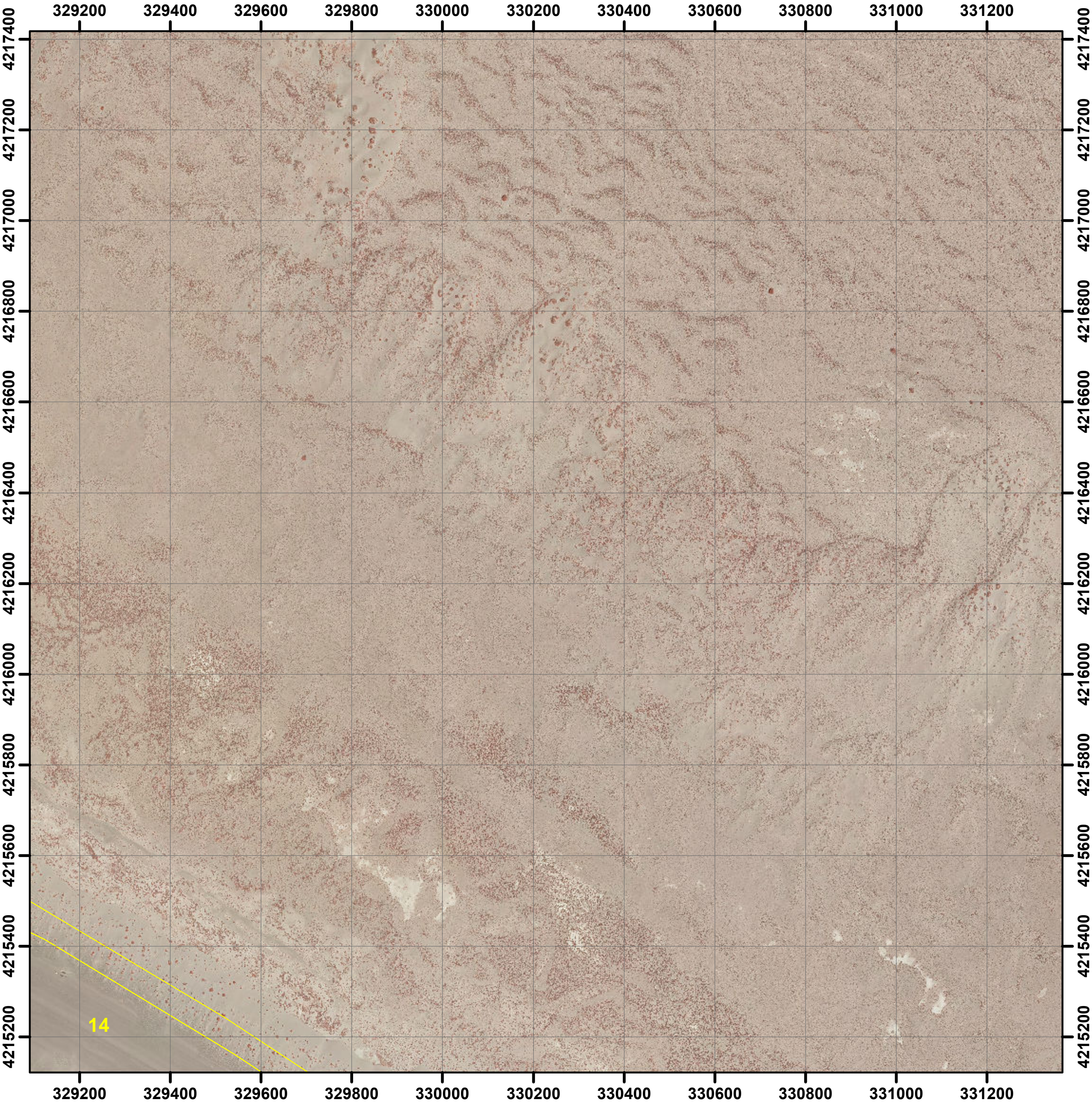
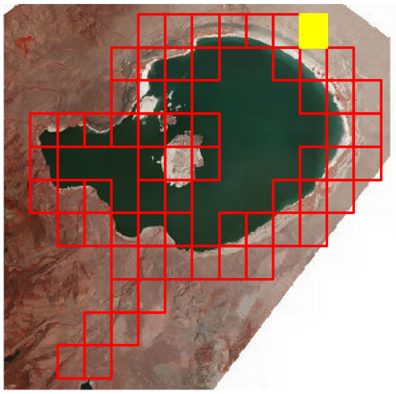


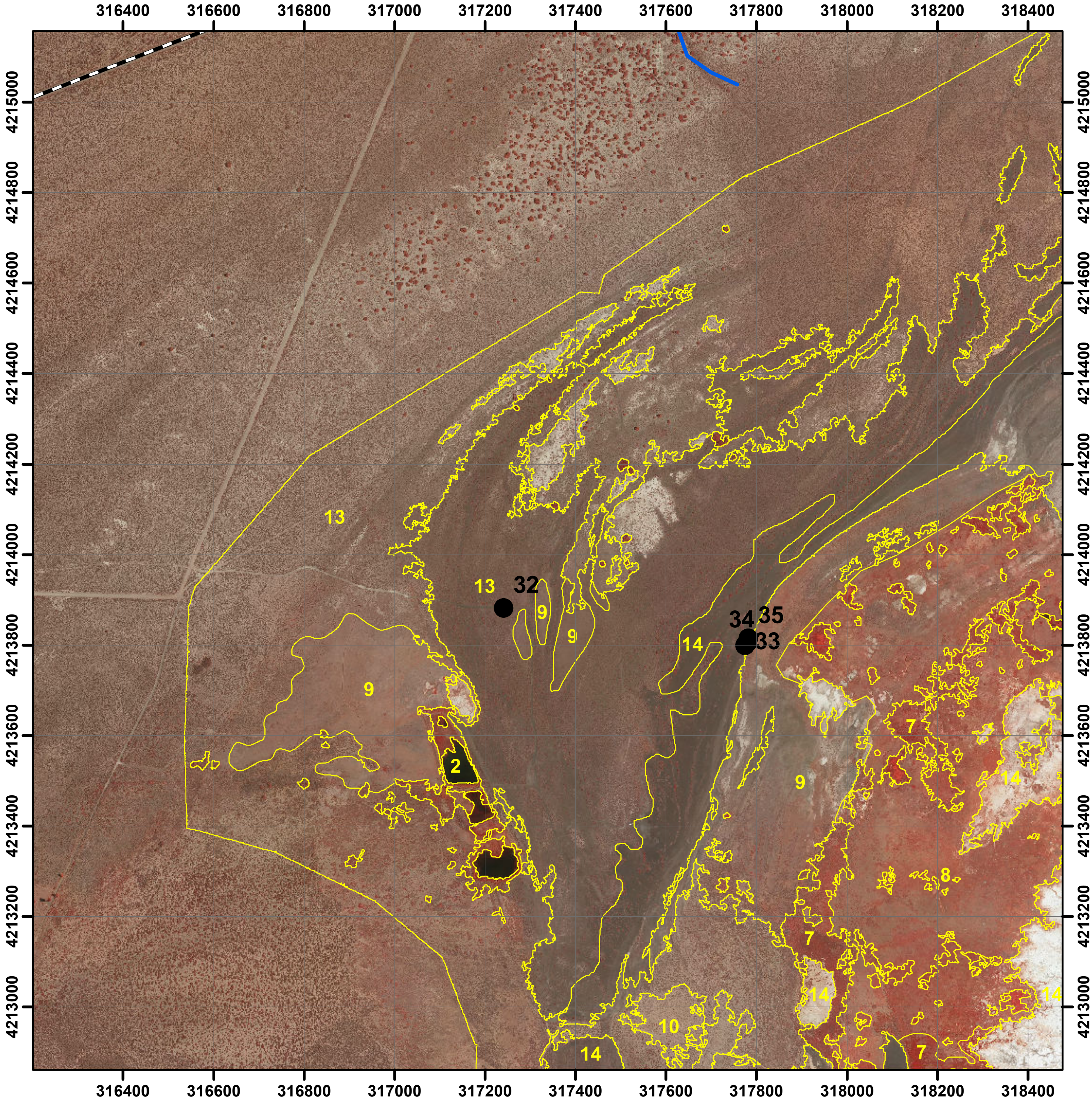
Mono Lake Landtype, 2014 Conditions

Map A11

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made
● Photopoint



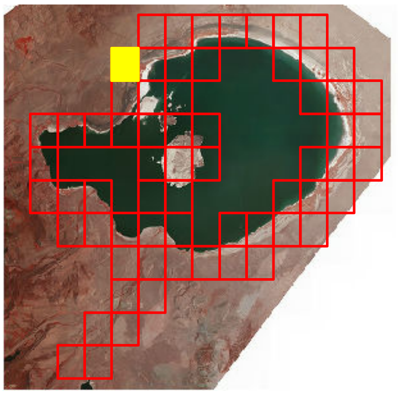
Note: Great Basin scrub is the combination of upland scrub, rabbitbrush, eolian, and pinyon woodland landtypes delineated in 2014; dry meadow/forb is rabbitbrush/meadow delineated in 2014; unvegetated is the combined area of barren lake bed and streambar delineated in 2014. Photopoints are linked to photographs in APPENDIX C.



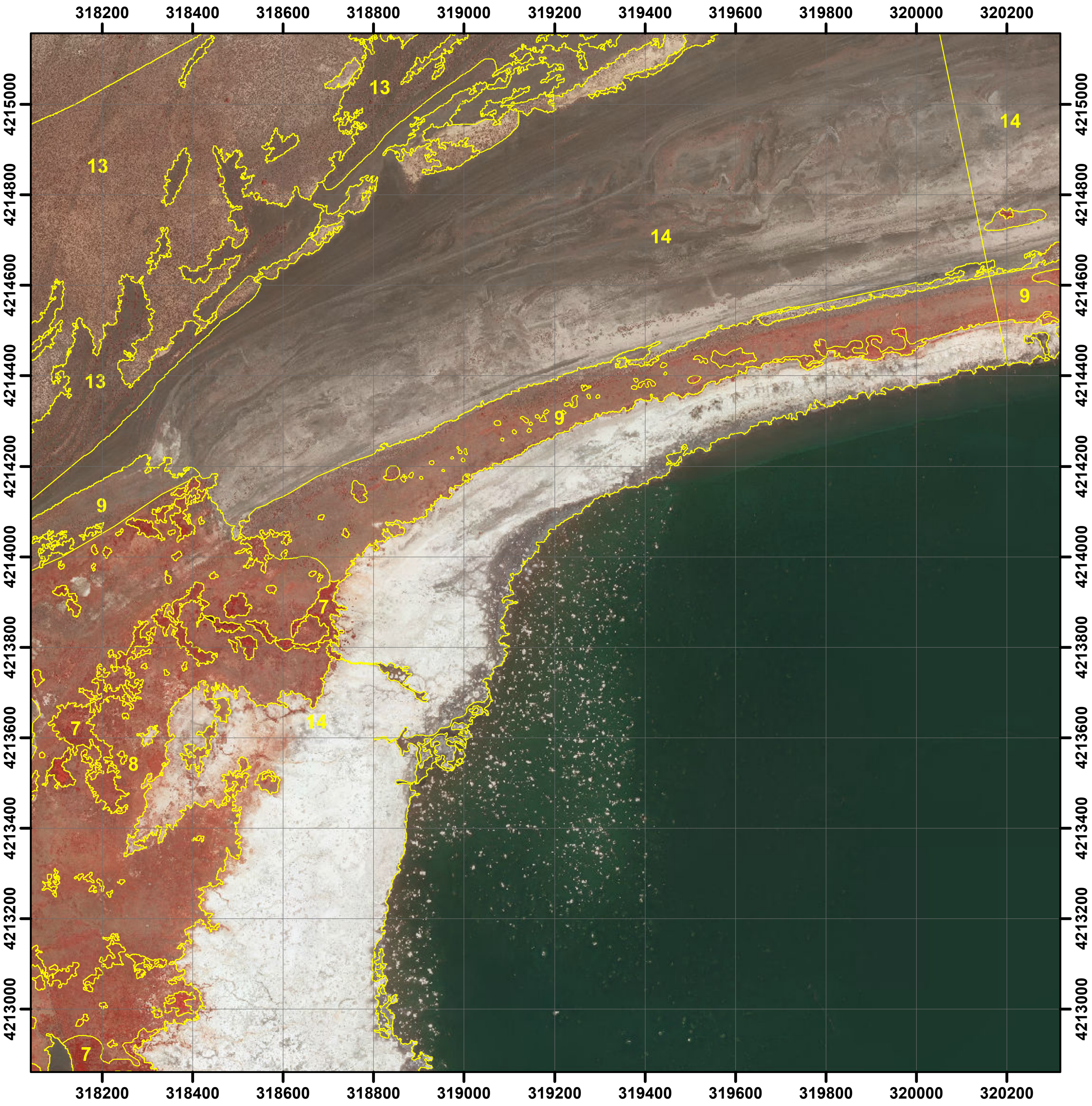
Mono Lake Landtype, 2014 Conditions

Map B4

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made
● Photopoint



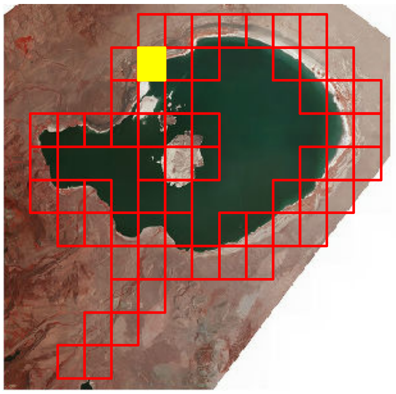
Note: Great Basin scrub is the combination of upland scrub, rabbitbrush, eolian, and pinyon woodland landtypes delineated in 2014; dry meadow/forb is rabbitbrush/meadow delineated in 2014; unvegetated is the combined area of barren lake bed and streambar delineated in 2014. Photopoints are linked to photographs in APPENDIX C.



Mono Lake Landtype, 2014 Conditions

Map B5

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made
● Photopoint



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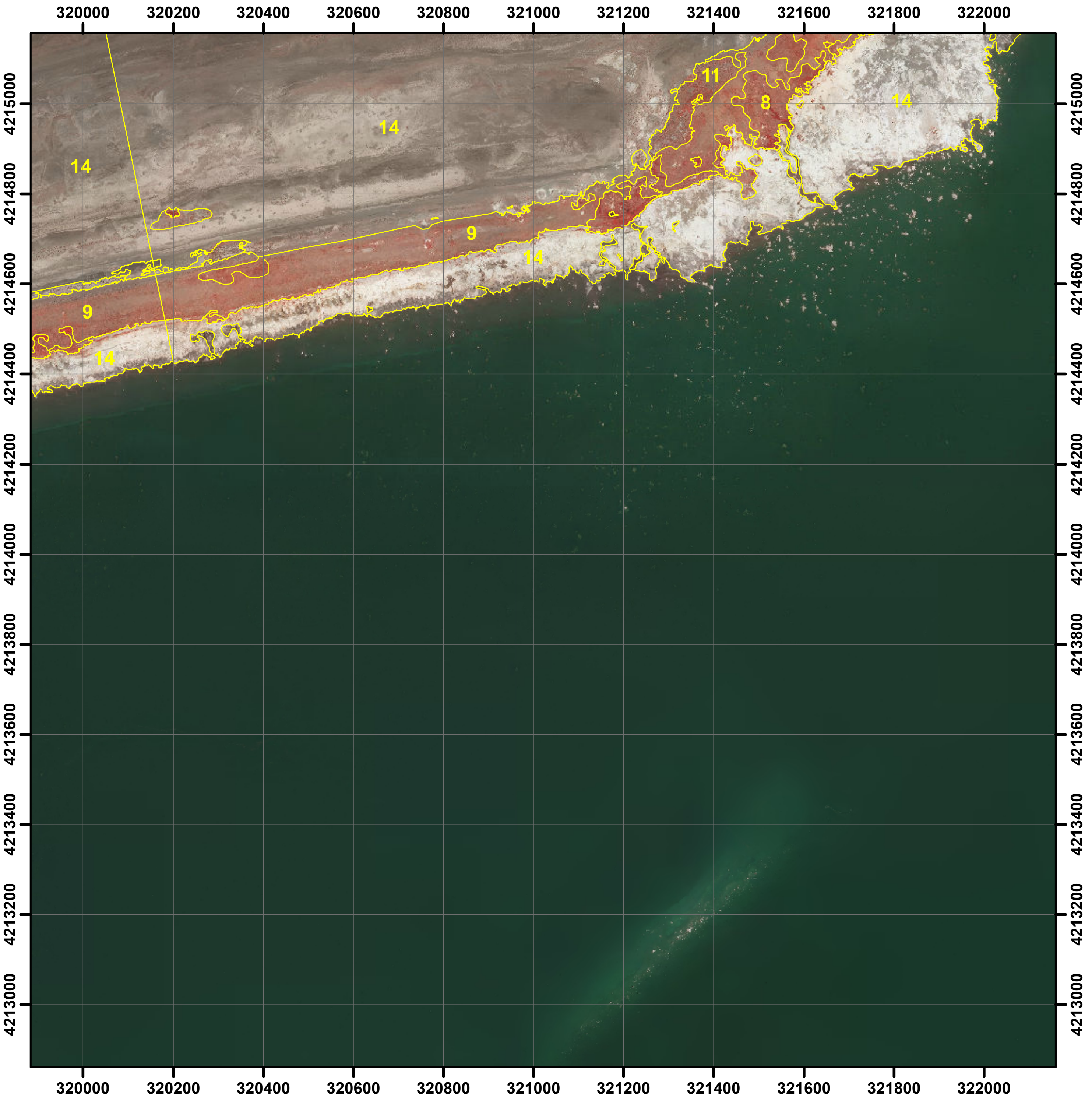
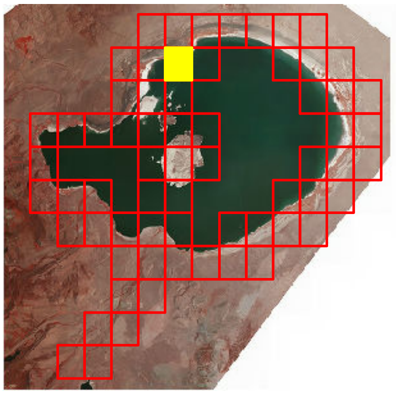


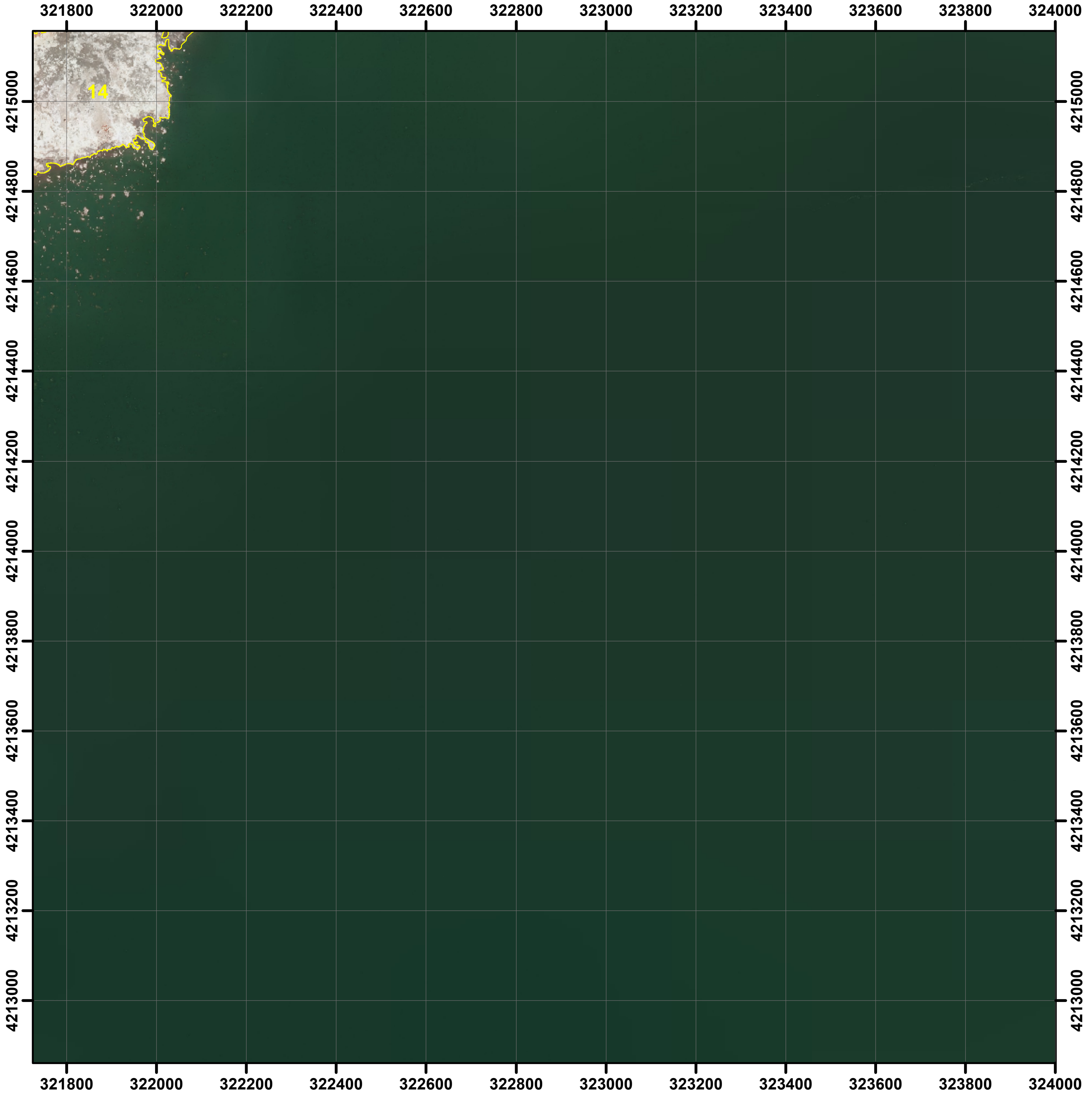
Mono Lake Landtype, 2014 Conditions

Map B6

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made
● Photopoint



Note: Great Basin scrub is the combination of upland scrub, rabbitbrush, eolian, and pinyon woodland landtypes delineated in 2014; dry meadow/forb is rabbitbrush/meadow delineated in 2014; unvegetated is the combined area of barren lake bed and streambar delineated in 2014. Photopoints are linked to photographs in APPENDIX C.



Mono Lake Landtype, 2014 Conditions

Map B7

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
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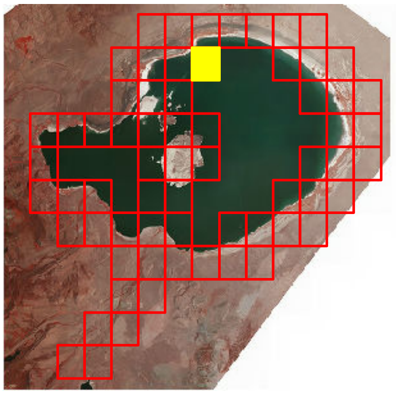
15 = Man-made
● Photopoint



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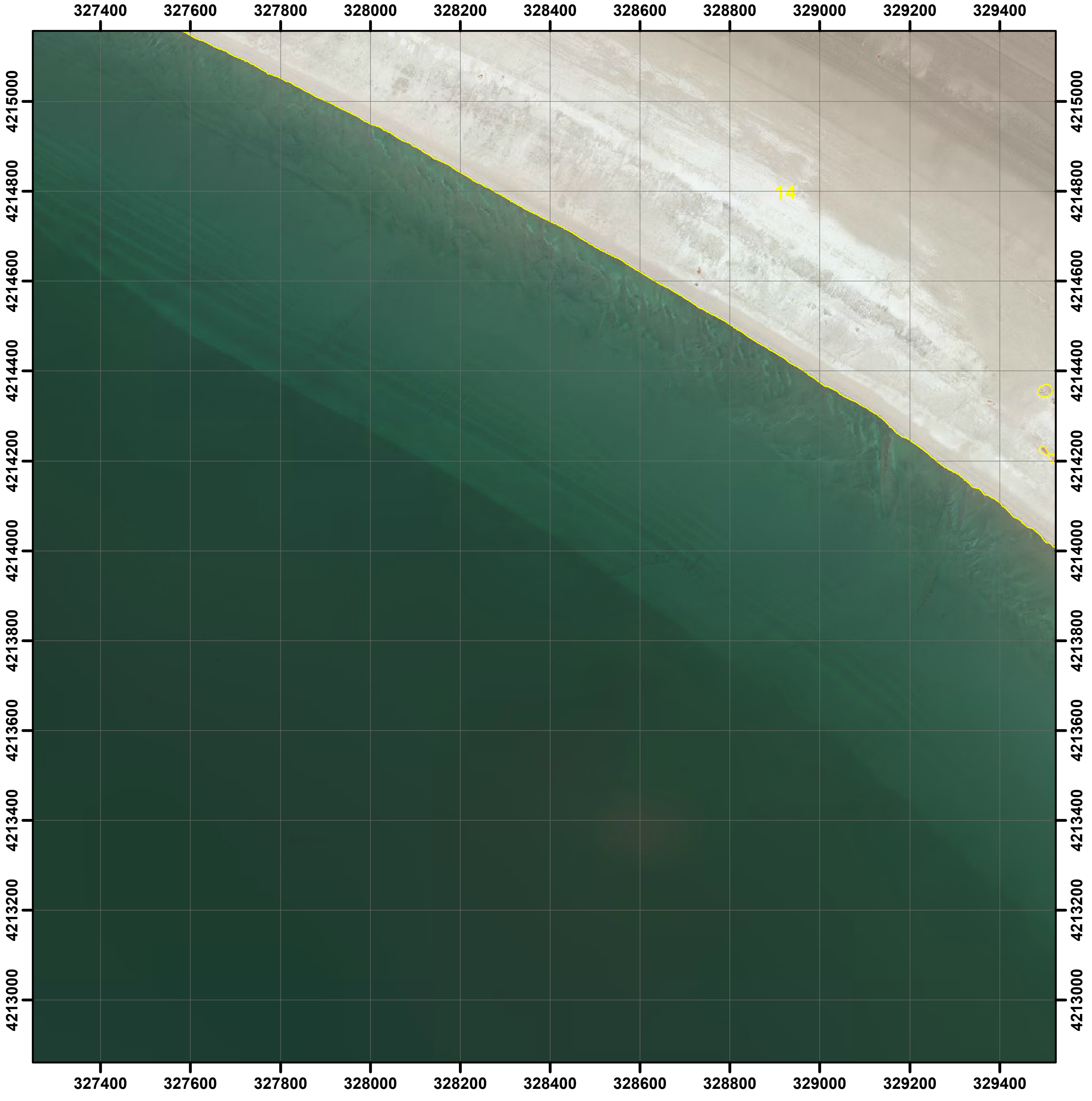

Mono Lake Landtype, 2014 Conditions
Map B10

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
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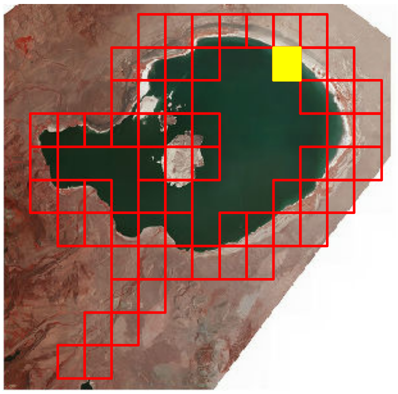
● Photopoint



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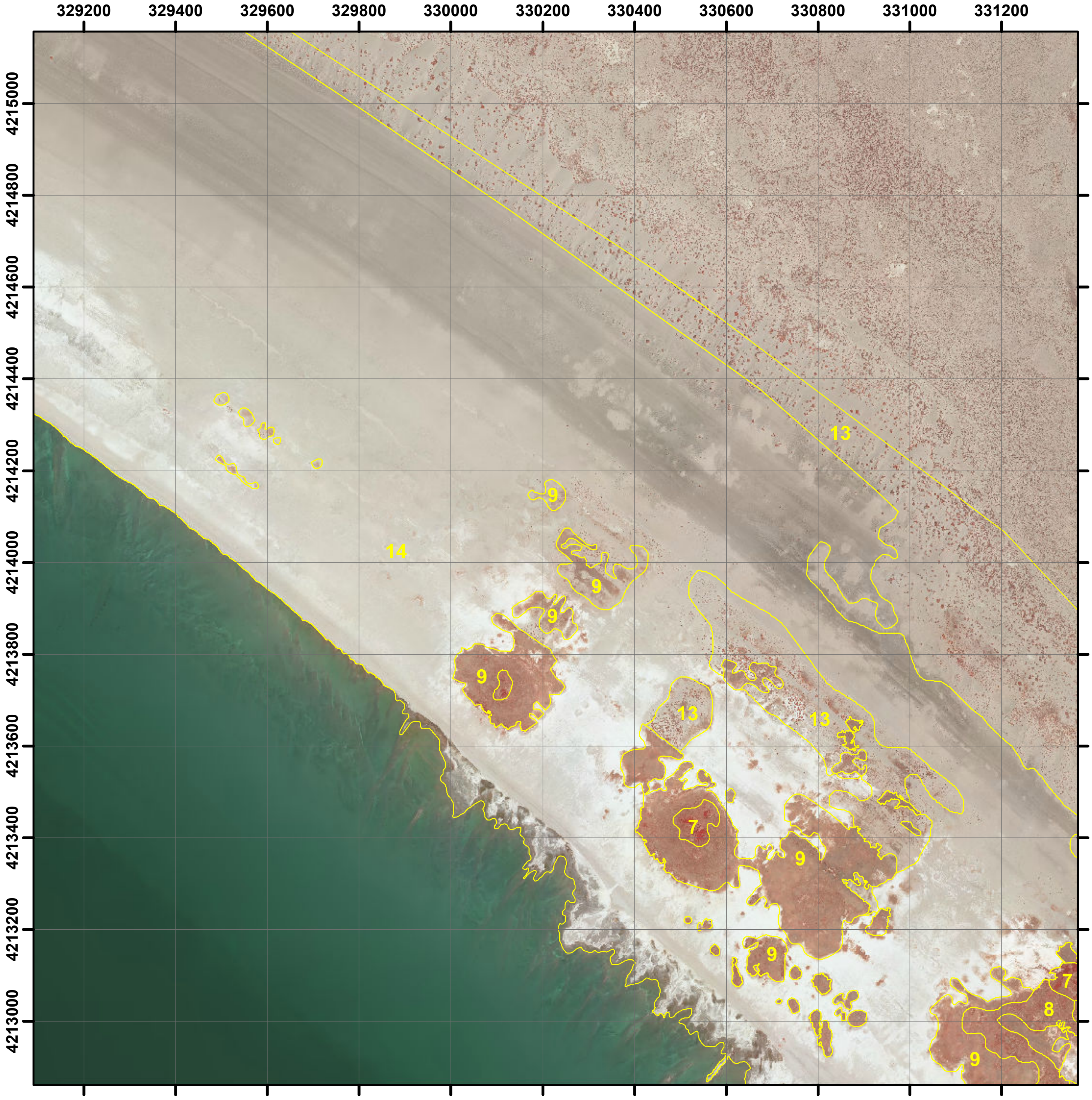

Mono Lake Landtype, 2014 Conditions

Map B11

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
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6 = Mudflat
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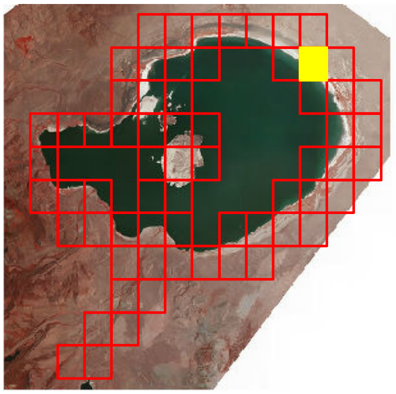

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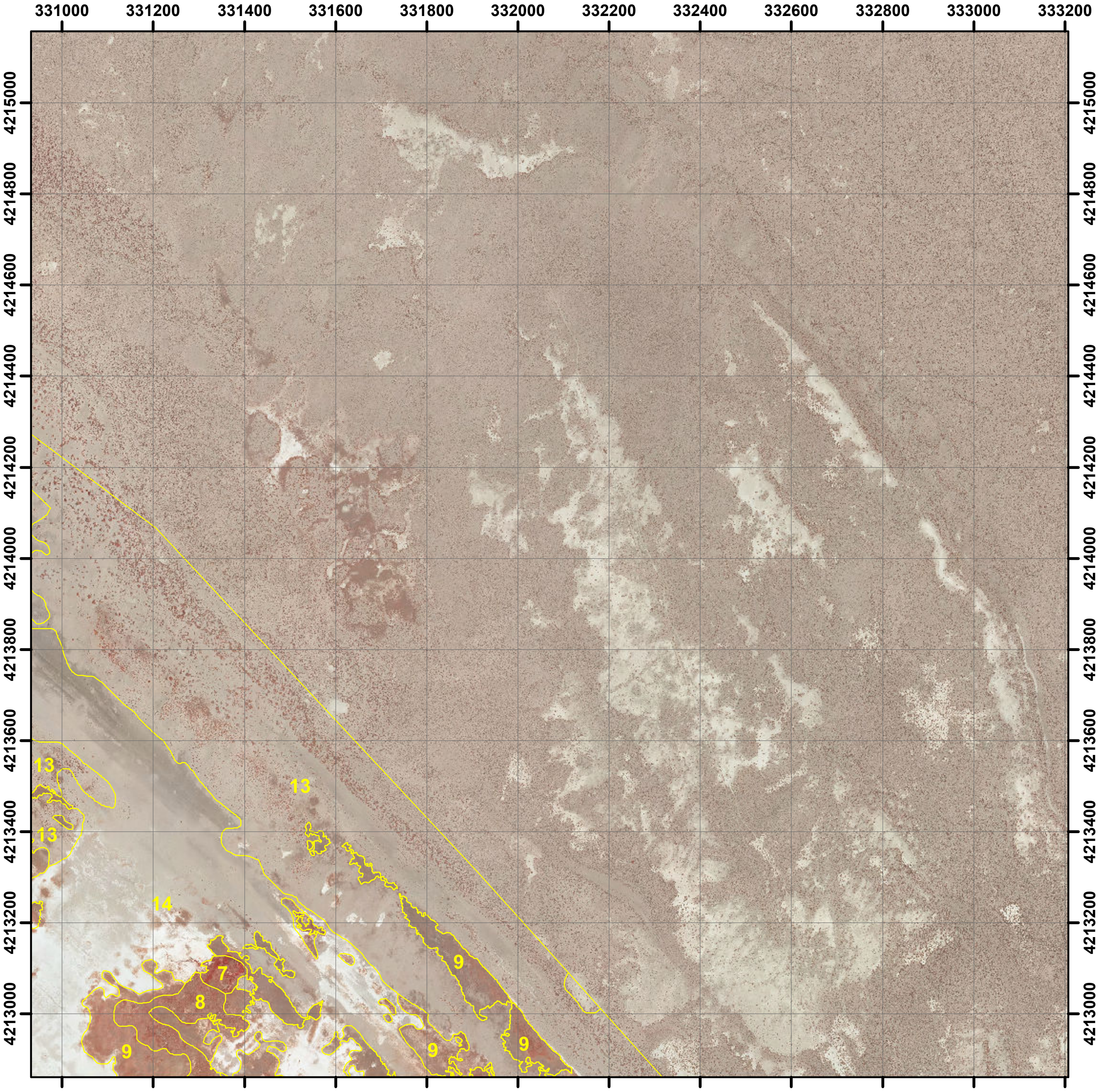
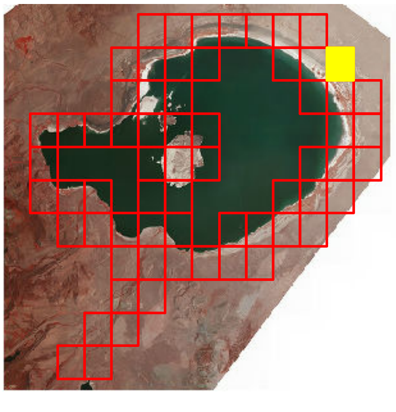


Mono Lake Landtype, 2014 Conditions

Map B12



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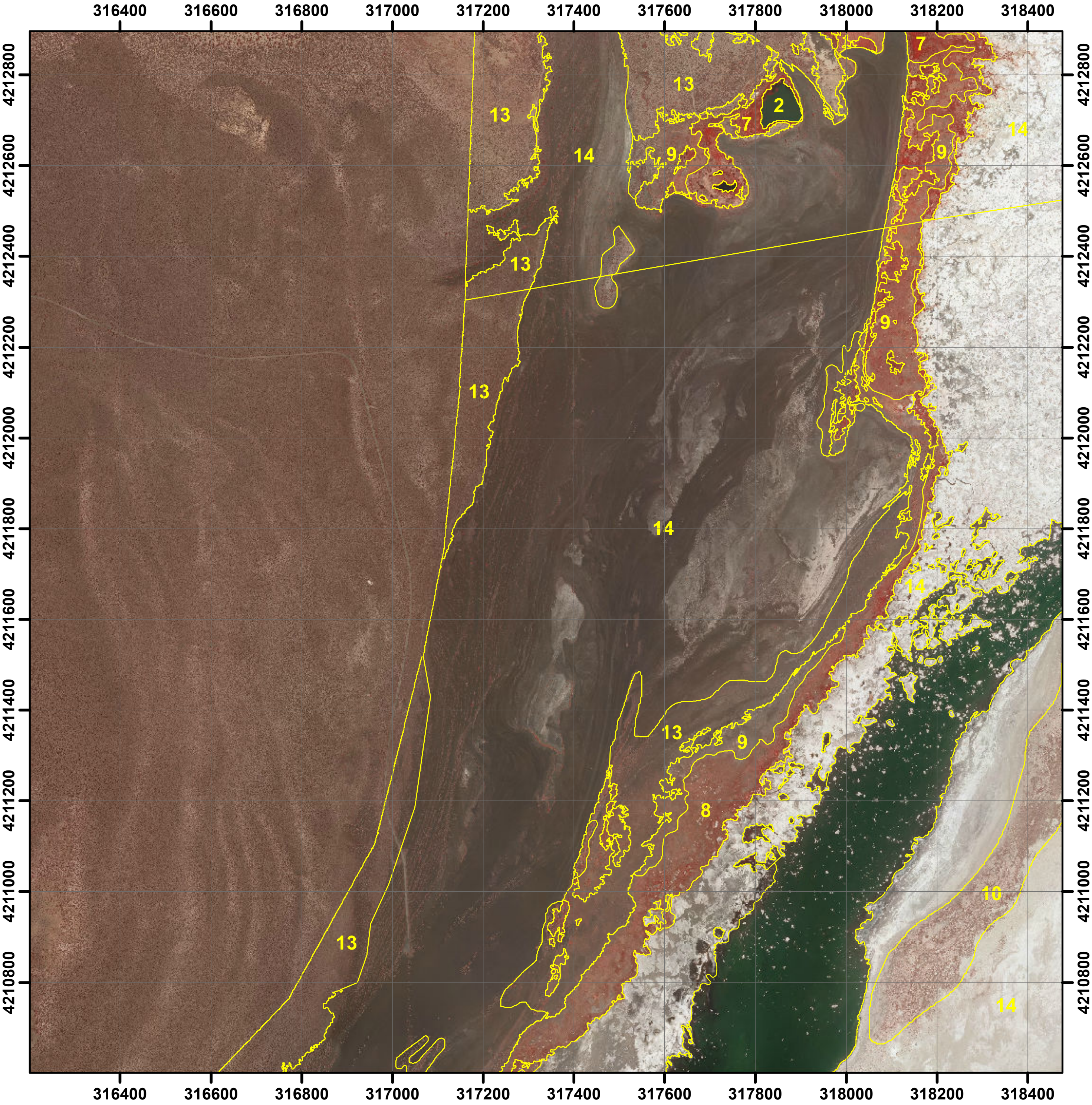
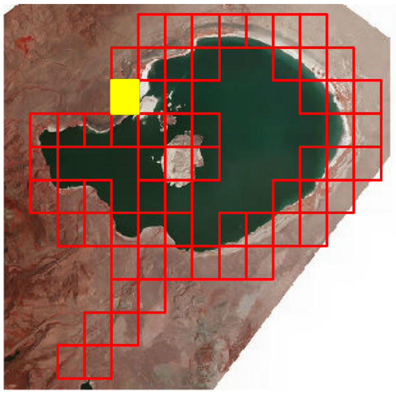


Mono Lake Landtype, 2014 Conditions
Map C4



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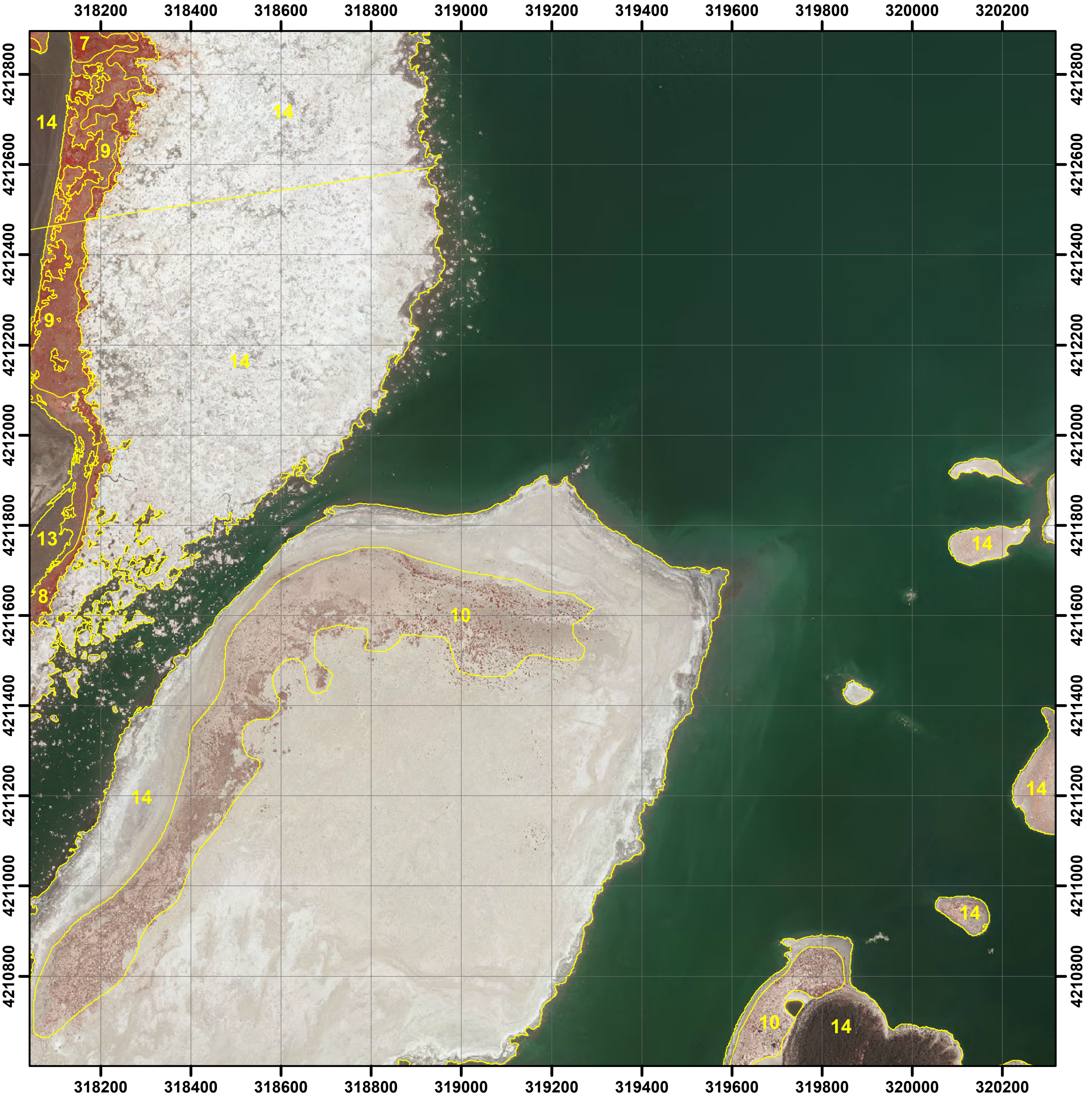
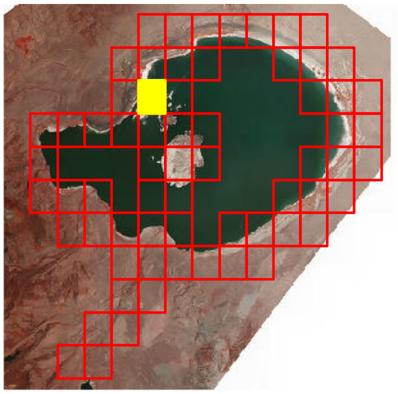


Mono Lake Landtype, 2014 Conditions
Map C5



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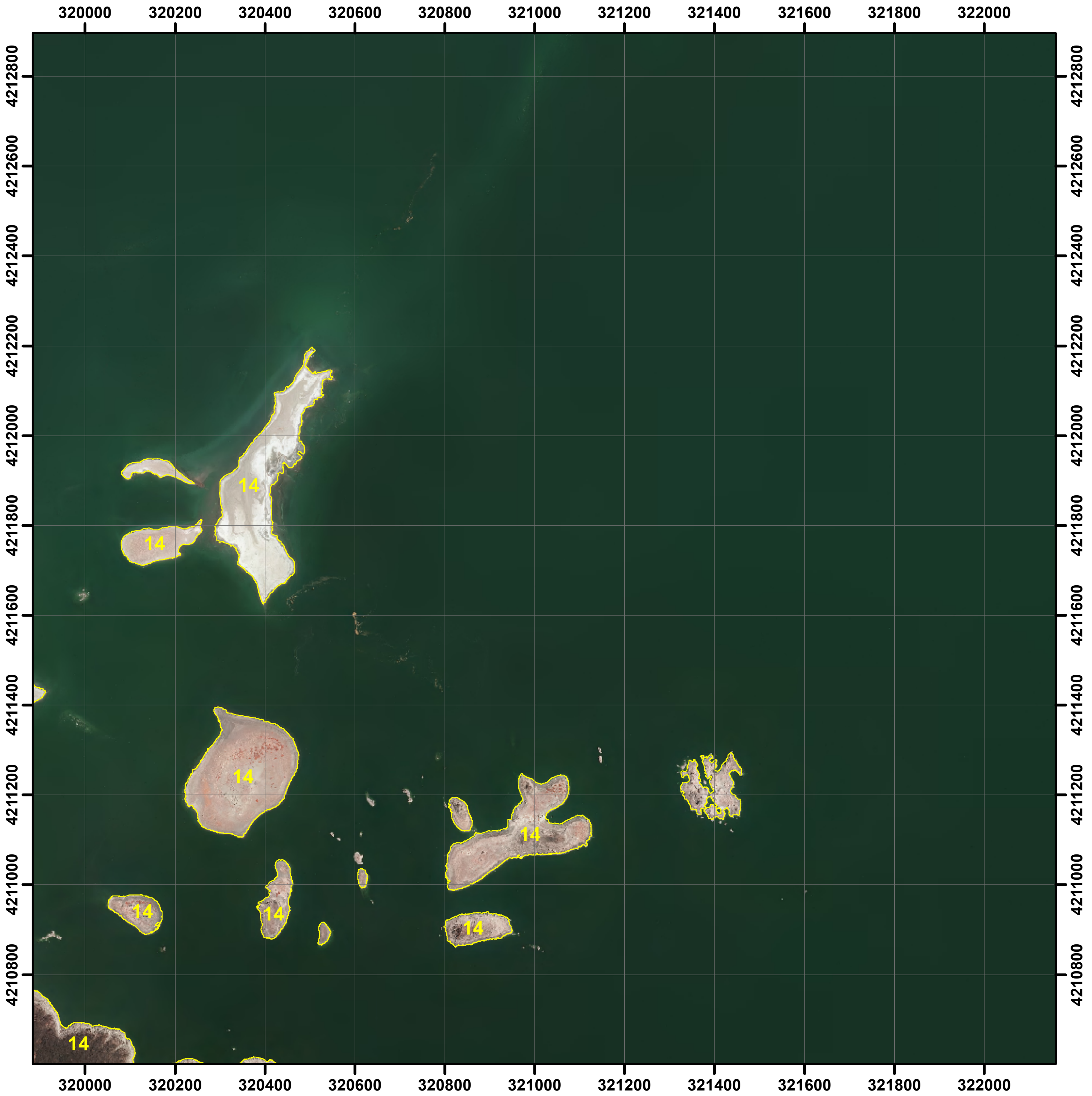
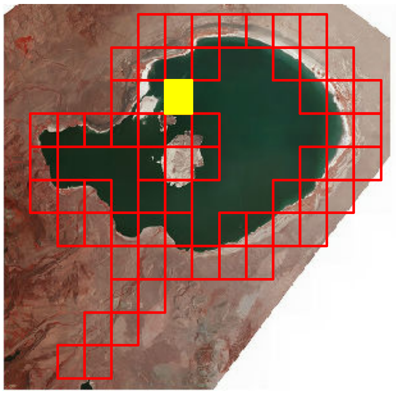


Mono Lake Landtype, 2014 Conditions
Map C6



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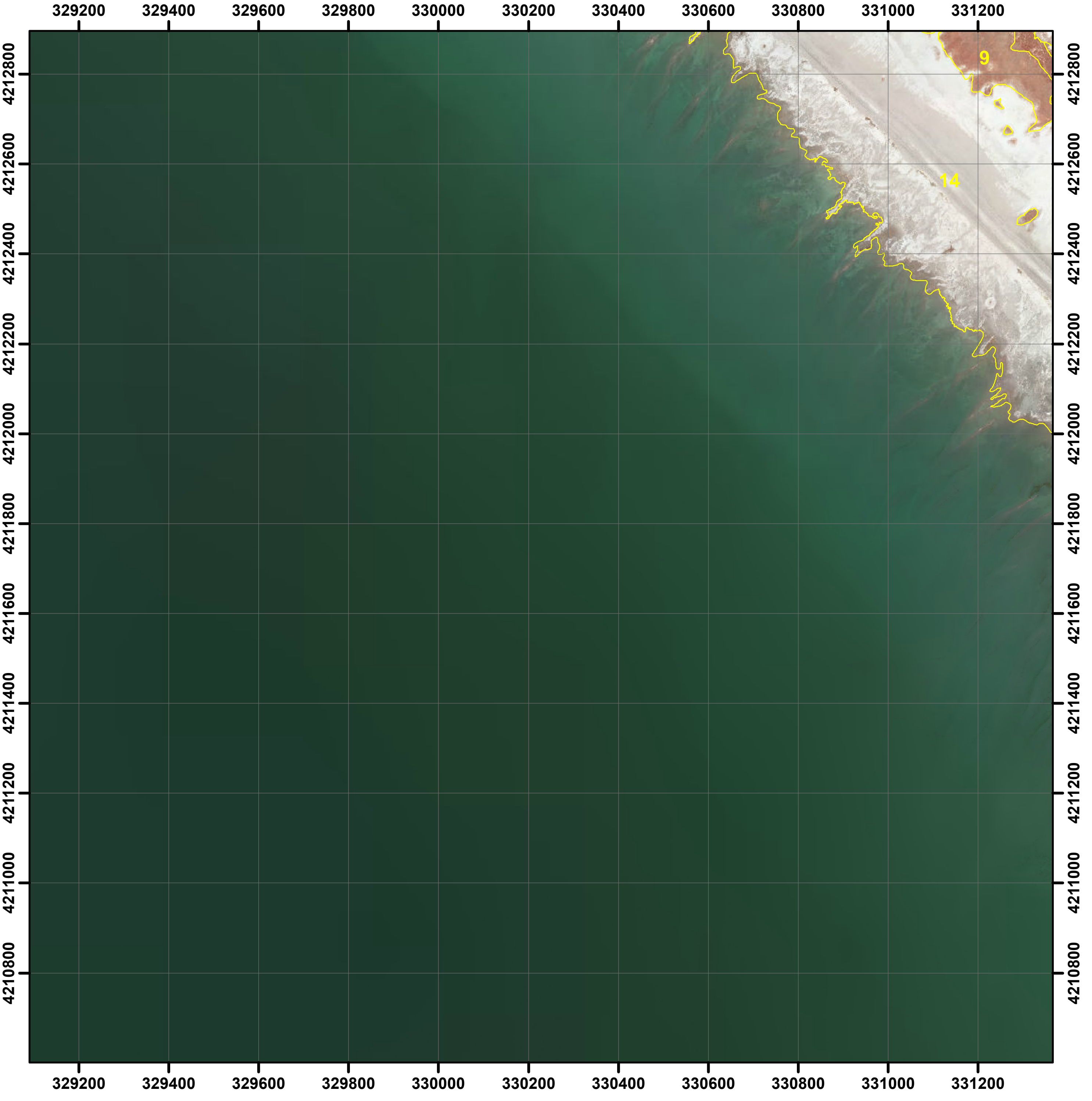
15 = Man-made
● Photopoint

Note: Great Basin scrub is the combination of upland scrub, rabbitbrush, eolian, and pinyon woodland landtypes delineated in 2014; dry meadow/forb is rabbitbrush/meadow delineated in 2014; unvegetated is the combined area of barren lake bed and streambar delineated in 2014. Photopoints are linked to photographs in APPENDIX C.

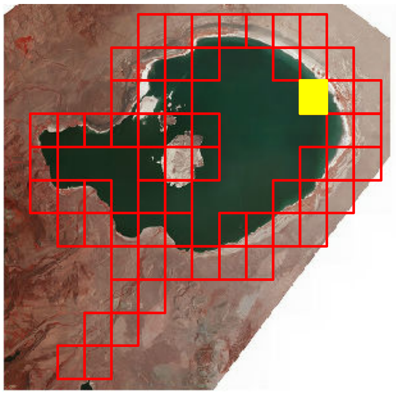


Mono Lake Landtype, 2014 Conditions

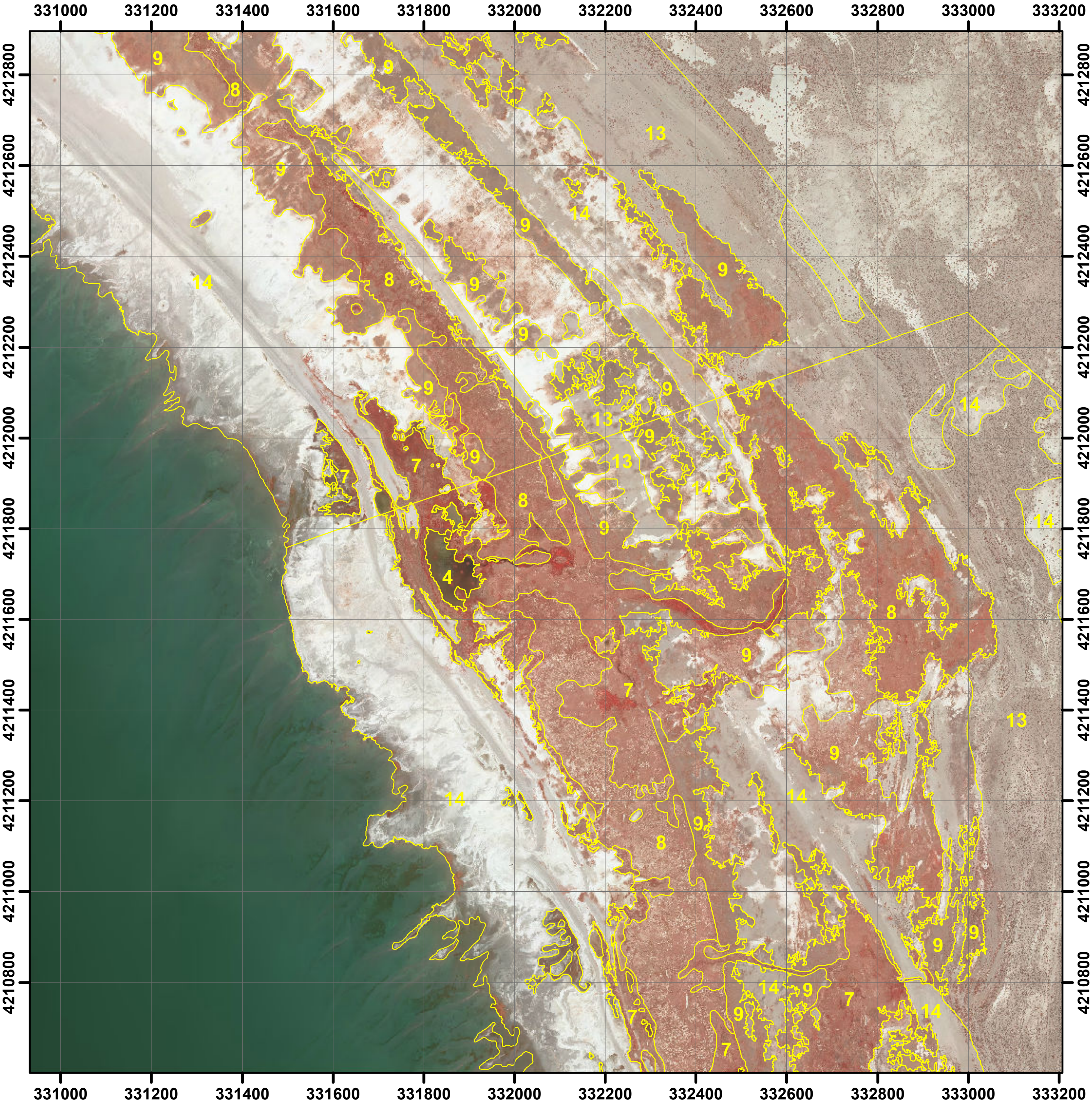
Map C11

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow

9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made
● Photopoint

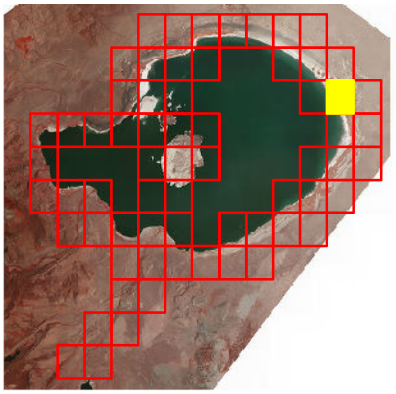


Note: Great Basin scrub is the combination of upland scrub, rabbitbrush, eolian, and pinyon woodland landtypes delineated in 2014; dry meadow/forb is rabbitbrush/meadow delineated in 2014; unvegetated is the combined area of barren lake bed and streambar delineated in 2014. Photopoints are linked to photographs in APPENDIX C.



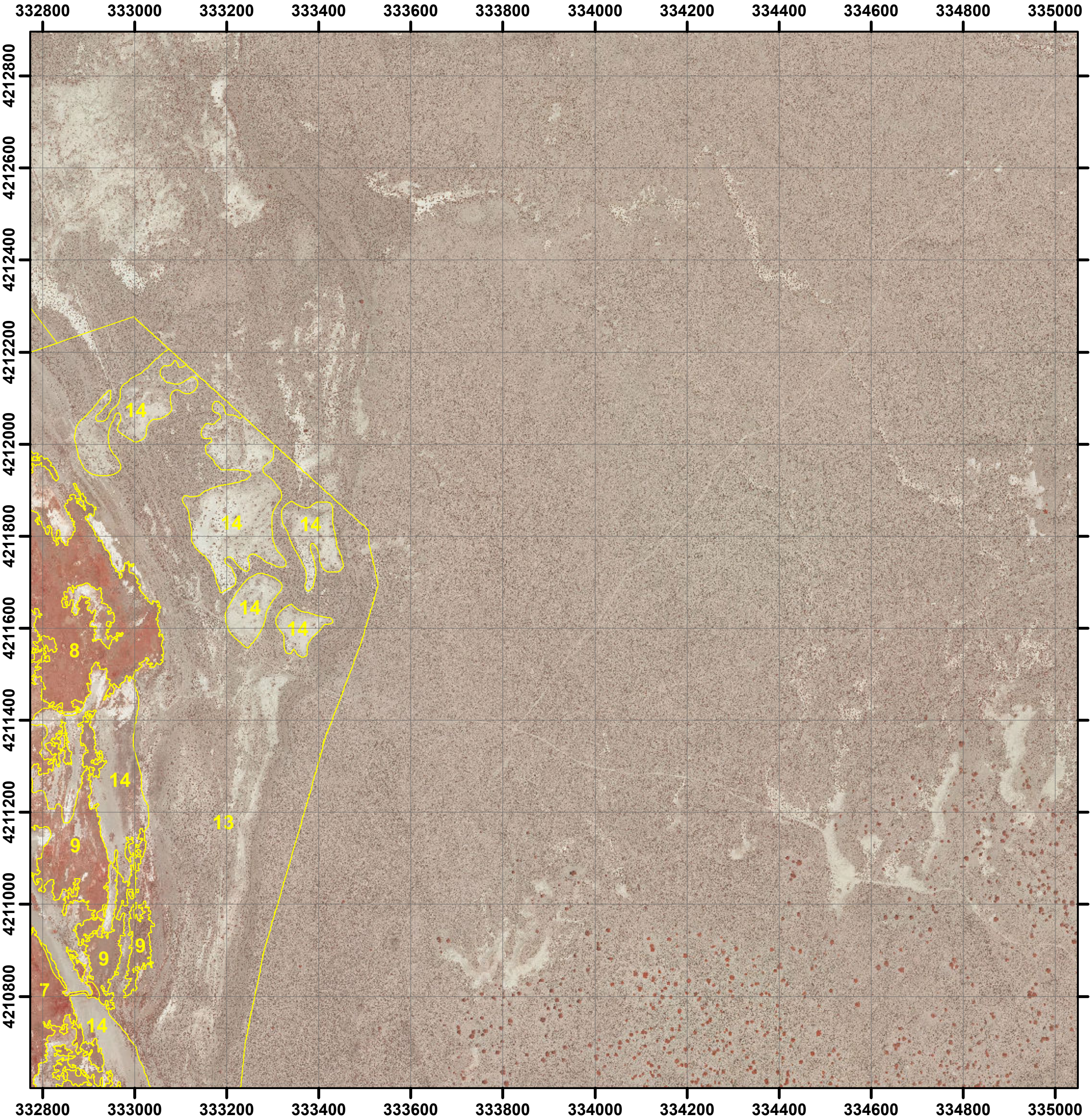
Mono Lake Landtype, 2014 Conditions

Map C12



1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made
● Photopoint

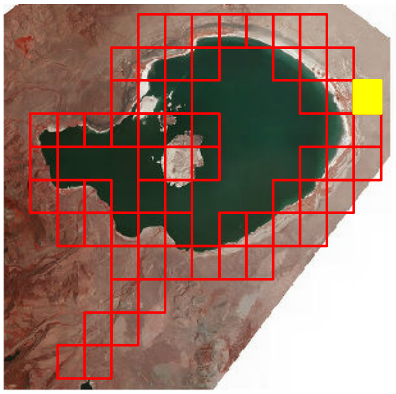
Note: Great Basin scrub is the combination of upland scrub, rabbitbrush, eolian, and pinyon woodland landtypes delineated in 2014; dry meadow/forb is rabbitbrush/meadow delineated in 2014; unvegetated is the combined area of barren lake bed and streambar delineated in 2014. Photopoints are linked to photographs in APPENDIX C.



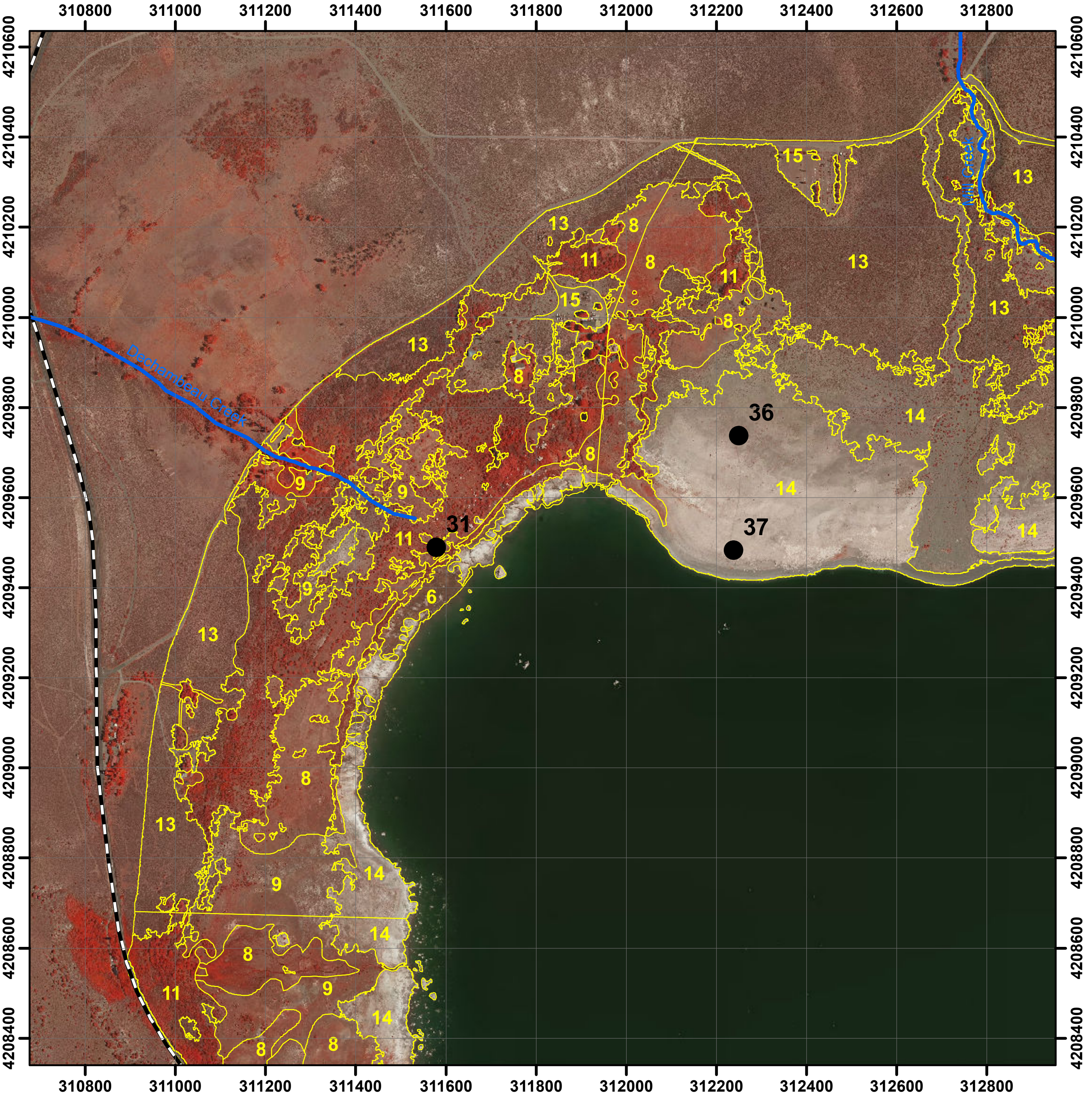
Mono Lake Landtype, 2014 Conditions

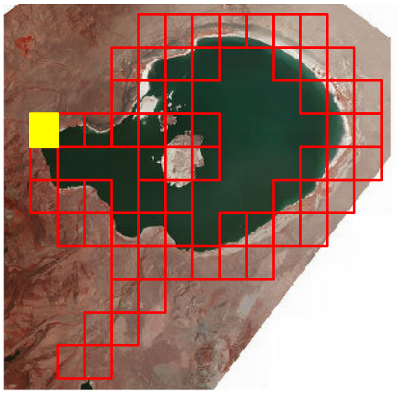
Map C13

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made
● Photopoint



Note: Great Basin scrub is the combination of upland scrub, rabbitbrush, eolian, and pinyon woodland landtypes delineated in 2014; dry meadow/forb is rabbitbrush/meadow delineated in 2014; unvegetated is the combined area of barren lake bed and streambar delineated in 2014. Photopoints are linked to photographs in APPENDIX C.



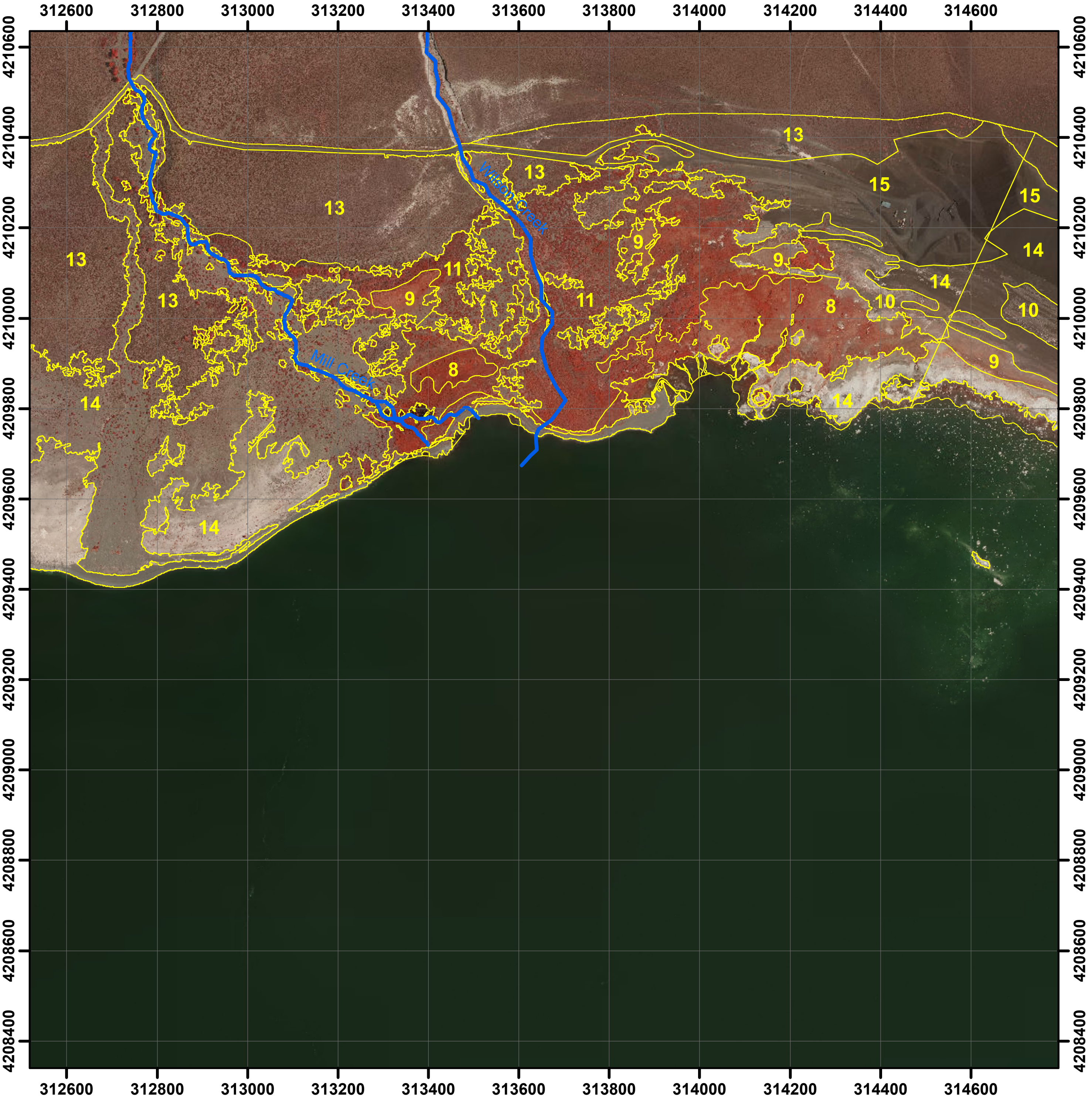


Mono Lake Landtype, 2014 Conditions

Map D1

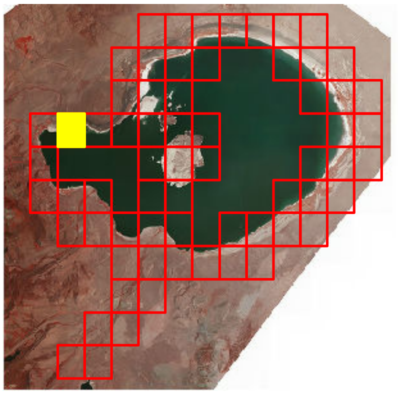
1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made
● Photopoint

Note: Great Basin scrub is the combination of upland scrub, rabbitbrush, eolian, and pinyon woodland landtypes delineated in 2014; dry meadow/forb is rabbitbrush/meadow delineated in 2014; unvegetated is the combined area of barren lake bed and streambar delineated in 2014. Photopoints are linked to photographs in APPENDIX C.



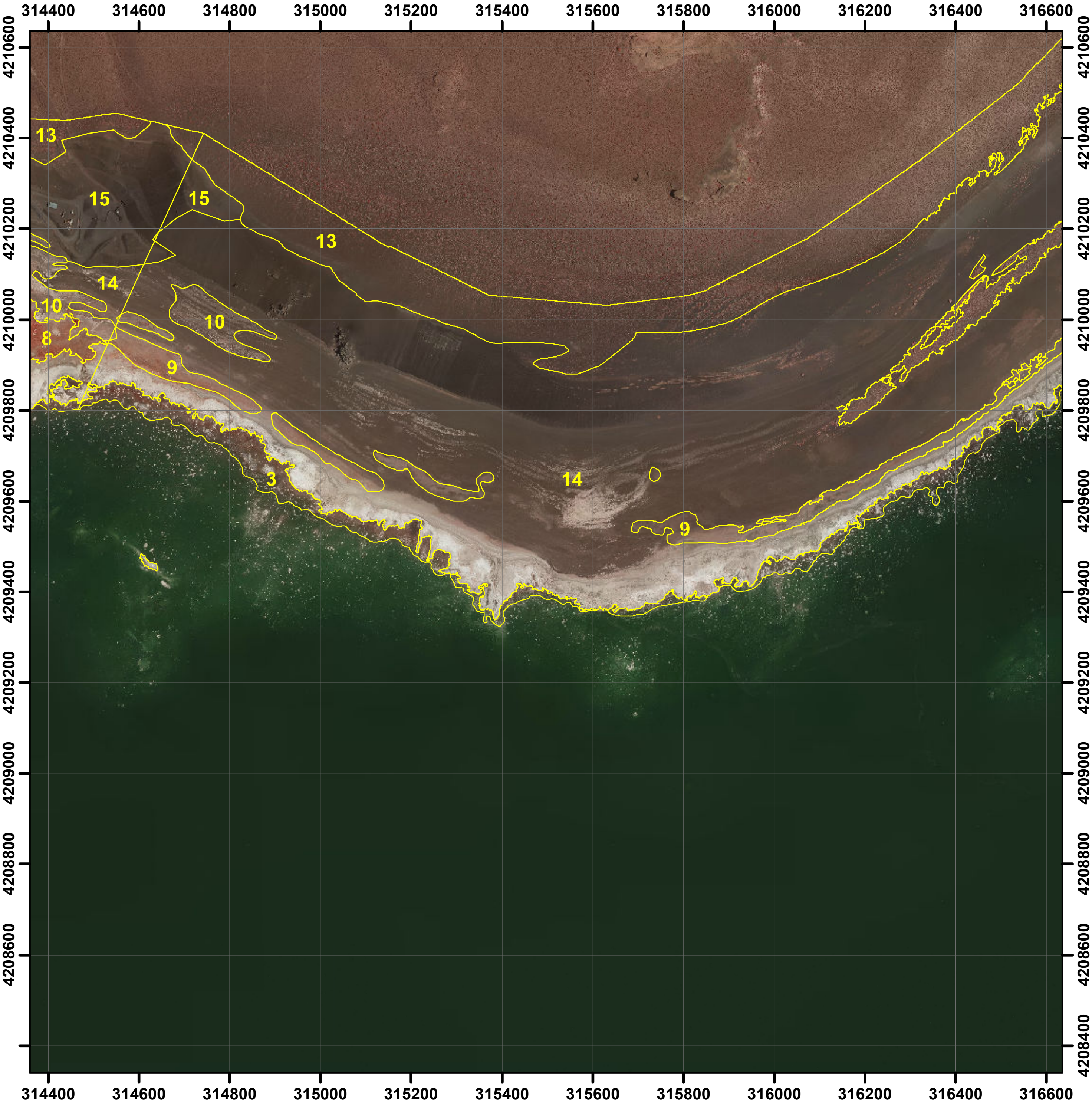
Mono Lake Landtype, 2014 Conditions

Map D2



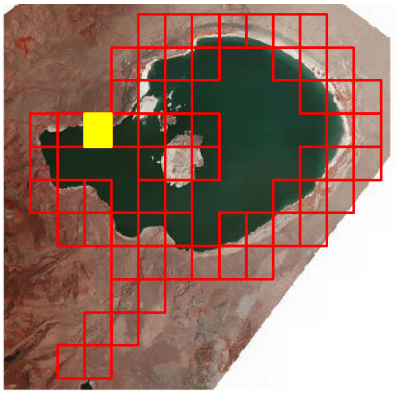
1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made
● Photopoint

Note: Great Basin scrub is the combination of upland scrub, rabbitbrush, eolian, and pinyon woodland landtypes delineated in 2014; dry meadow/forb is rabbitbrush/meadow delineated in 2014; unvegetated is the combined area of barren lake bed and streambar delineated in 2014. Photopoints are linked to photographs in APPENDIX C.



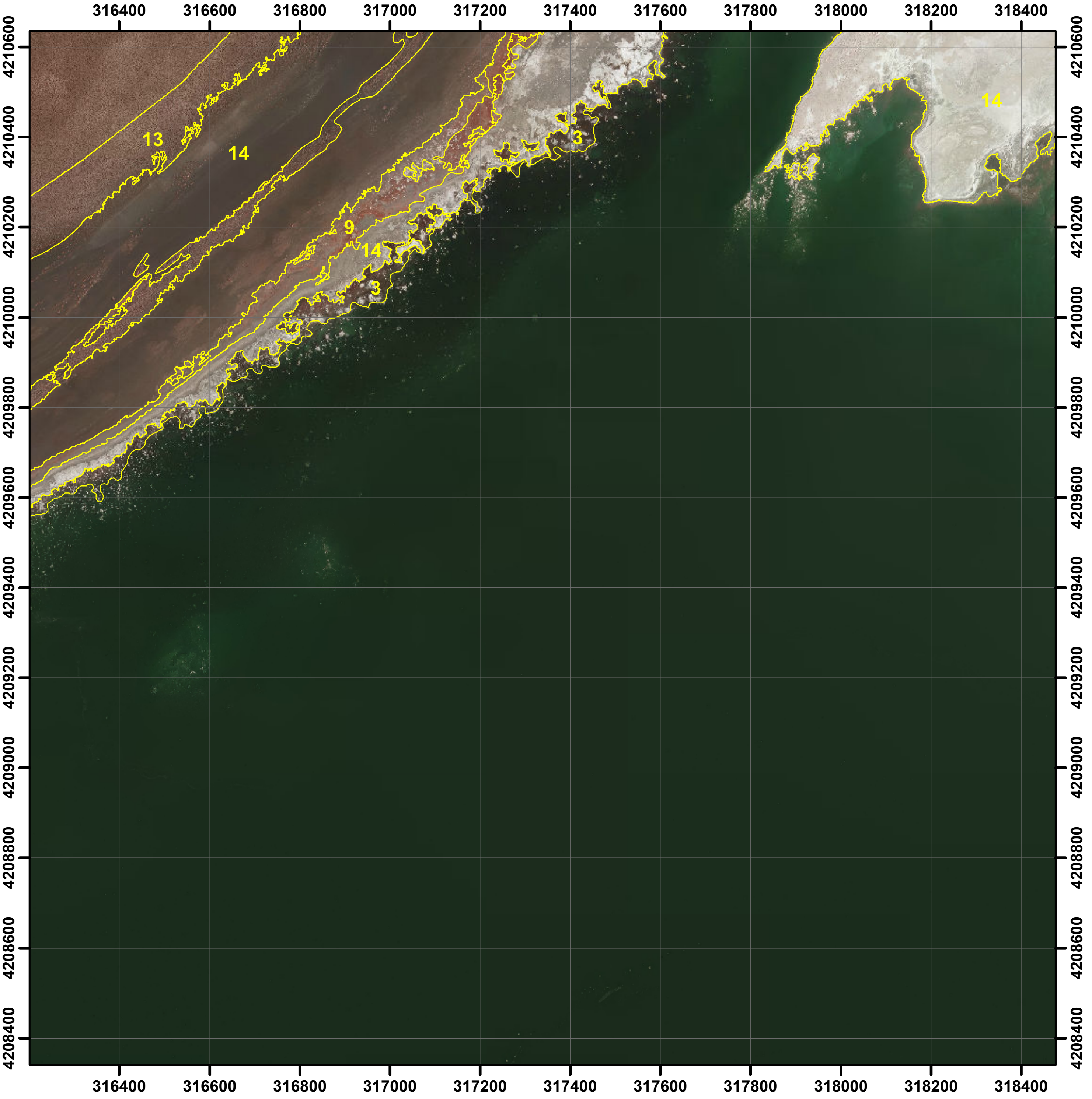
Mono Lake Landtype, 2014 Conditions

Map D3



1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made
● Photopoint

Note: Great Basin scrub is the combination of upland scrub, rabbitbrush, eolian, and pinyon woodland landtypes delineated in 2014; dry meadow/forb is rabbitbrush/meadow delineated in 2014; unvegetated is the combined area of barren lake bed and streambar delineated in 2014. Photopoints are linked to photographs in APPENDIX C.

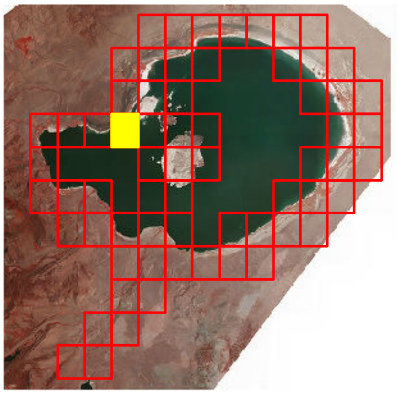


Mono Lake Landtype, 2014 Conditions

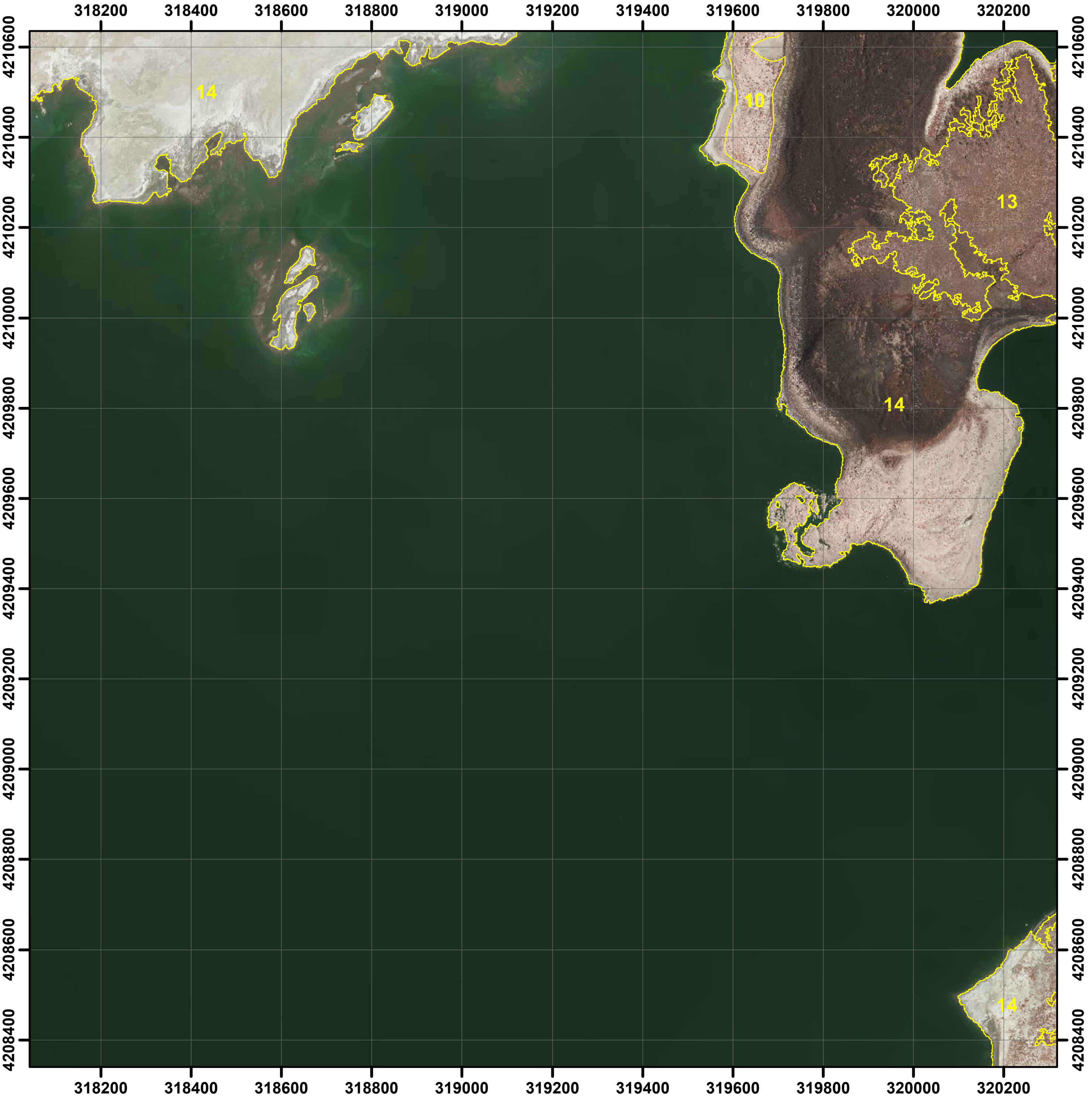
Map D4

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow

9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made
● Photopoint

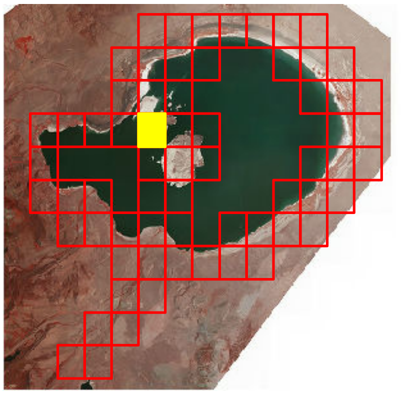


Note: Great Basin scrub is the combination of upland scrub, rabbitbrush, eolian, and pinyon woodland landtypes delineated in 2014; dry meadow/forb is rabbitbrush/meadow delineated in 2014; unvegetated is the combined area of barren lake bed and streambar delineated in 2014. Photopoints are linked to photographs in APPENDIX C.



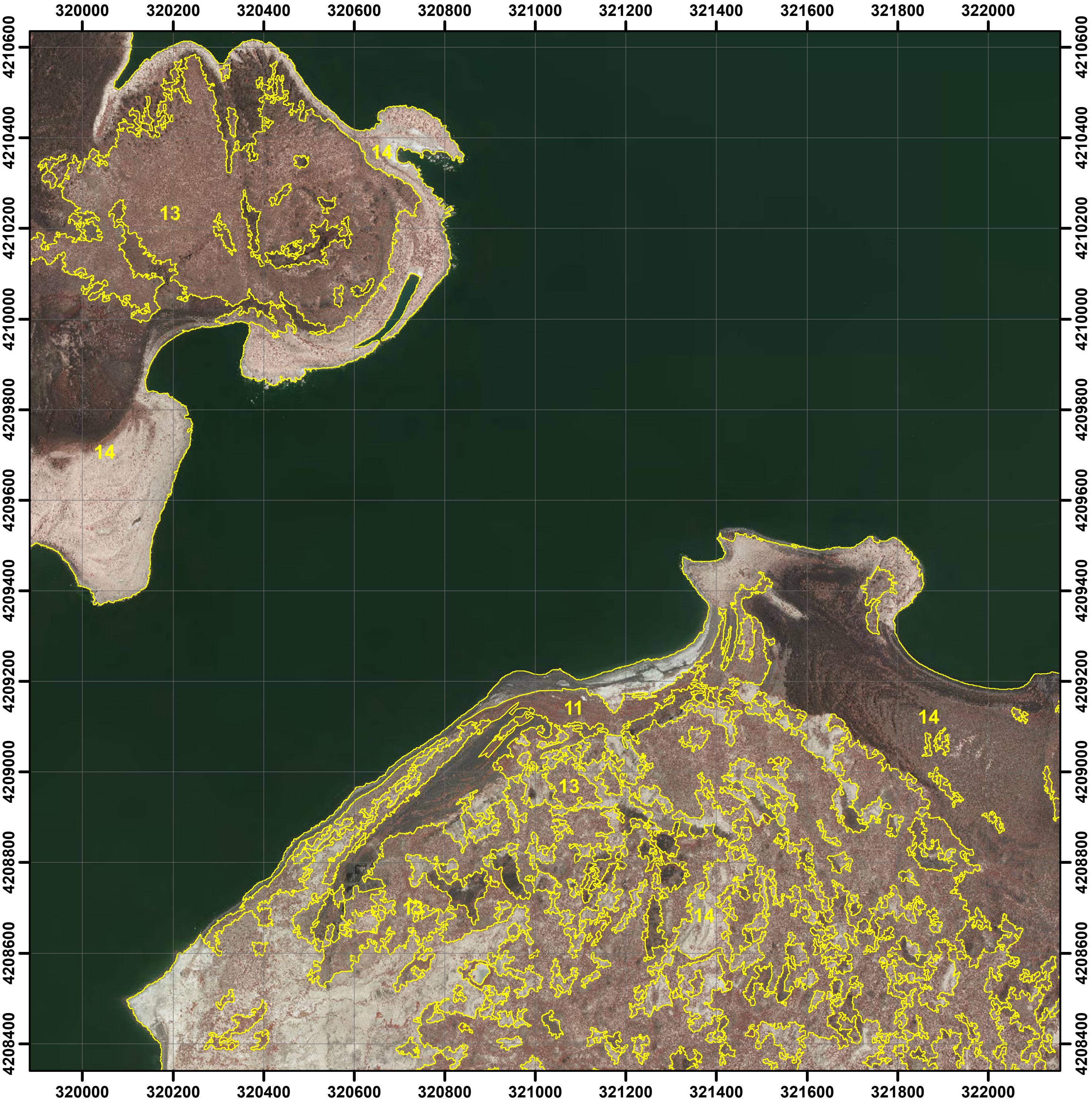
Mono Lake Landtype, 2014 Conditions

Map D5



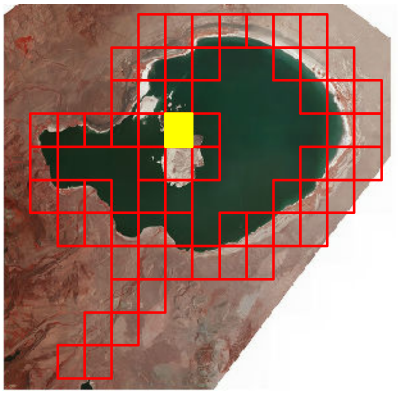
1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made
● Photopoint

Note: Great Basin scrub is the combination of upland scrub, rabbitbrush, eolian, and pinyon woodland landtypes delineated in 2014; dry meadow/forb is rabbitbrush/meadow delineated in 2014; unvegetated is the combined area of barren lake bed and streambar delineated in 2014. Photopoints are linked to photographs in APPENDIX C.



Mono Lake Landtype, 2014 Conditions
Map D6

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made
● Photopoint

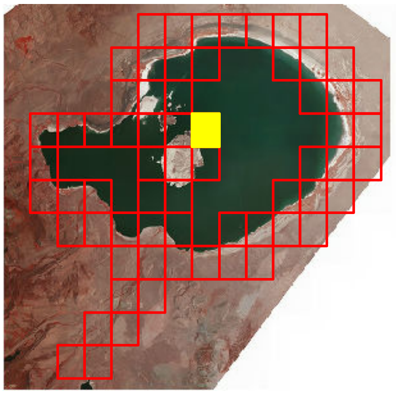


Note: Great Basin scrub is the combination of upland scrub, rabbitbrush, eolian, and pinyon woodland landtypes delineated in 2014; dry meadow/forb is rabbitbrush/meadow delineated in 2014; unvegetated is the combined area of barren lake bed and streambar delineated in 2014. Photopoints are linked to photographs in APPENDIX C.

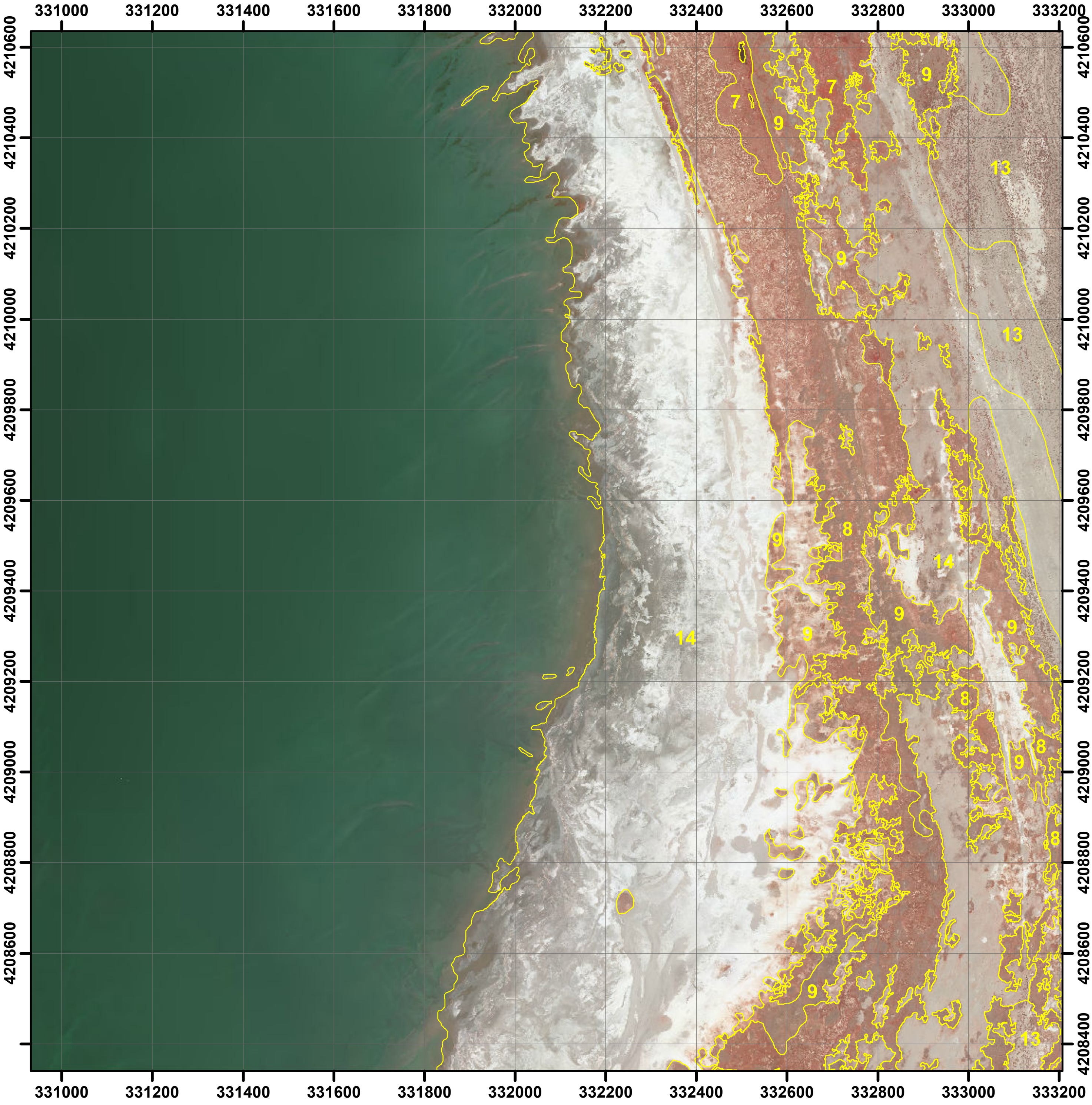
Mono Lake Landtype, 2014 Conditions

Map D7

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made
● Photopoint



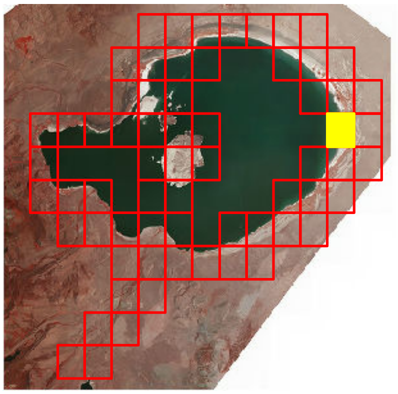
Note: Great Basin scrub is the combination of upland scrub, rabbitbrush, eolian, and pinyon woodland landtypes delineated in 2014; dry meadow/forb is rabbitbrush/meadow delineated in 2014; unvegetated is the combined area of barren lake bed and streambar delineated in 2014. Photopoints are linked to photographs in APPENDIX C.



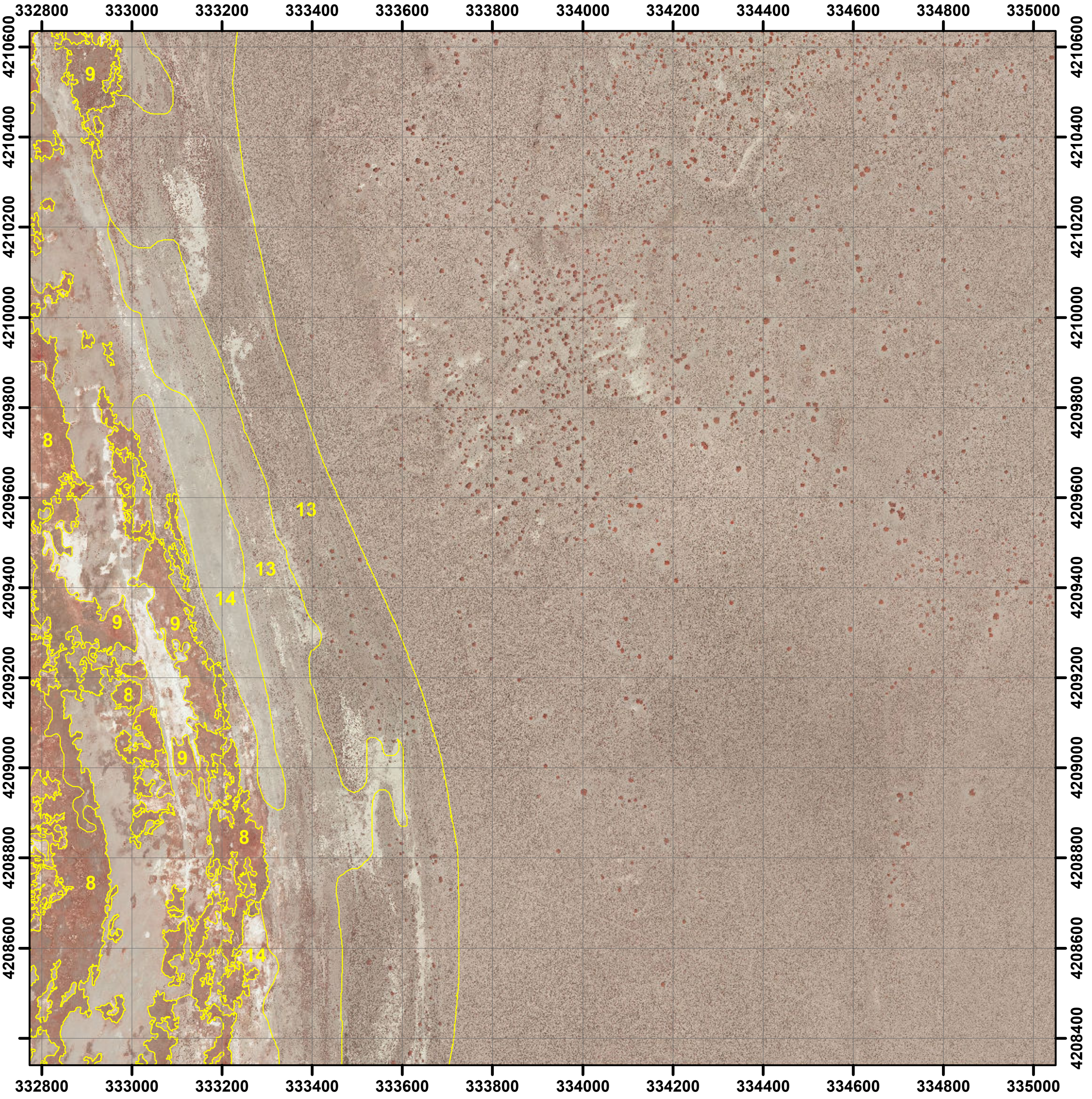
Mono Lake Landtype, 2014 Conditions

Map D12

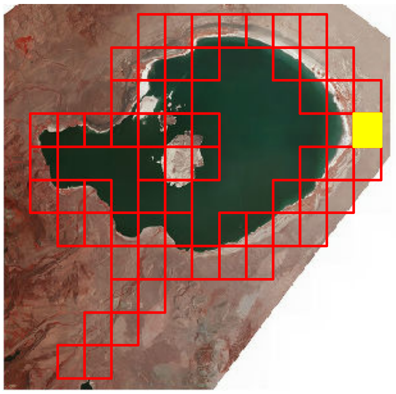
1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made
● Photopoint



Note: Great Basin scrub is the combination of upland scrub, rabbitbrush, eolian, and pinyon woodland landtypes delineated in 2014; dry meadow/forb is rabbitbrush/meadow delineated in 2014; unvegetated is the combined area of barren lake bed and streambar delineated in 2014. Photopoints are linked to photographs in APPENDIX C.



Mono Lake Landtype, 2014 Conditions
Map D13



1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
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12 = Riparian woodland
13 = Great Basin scrub
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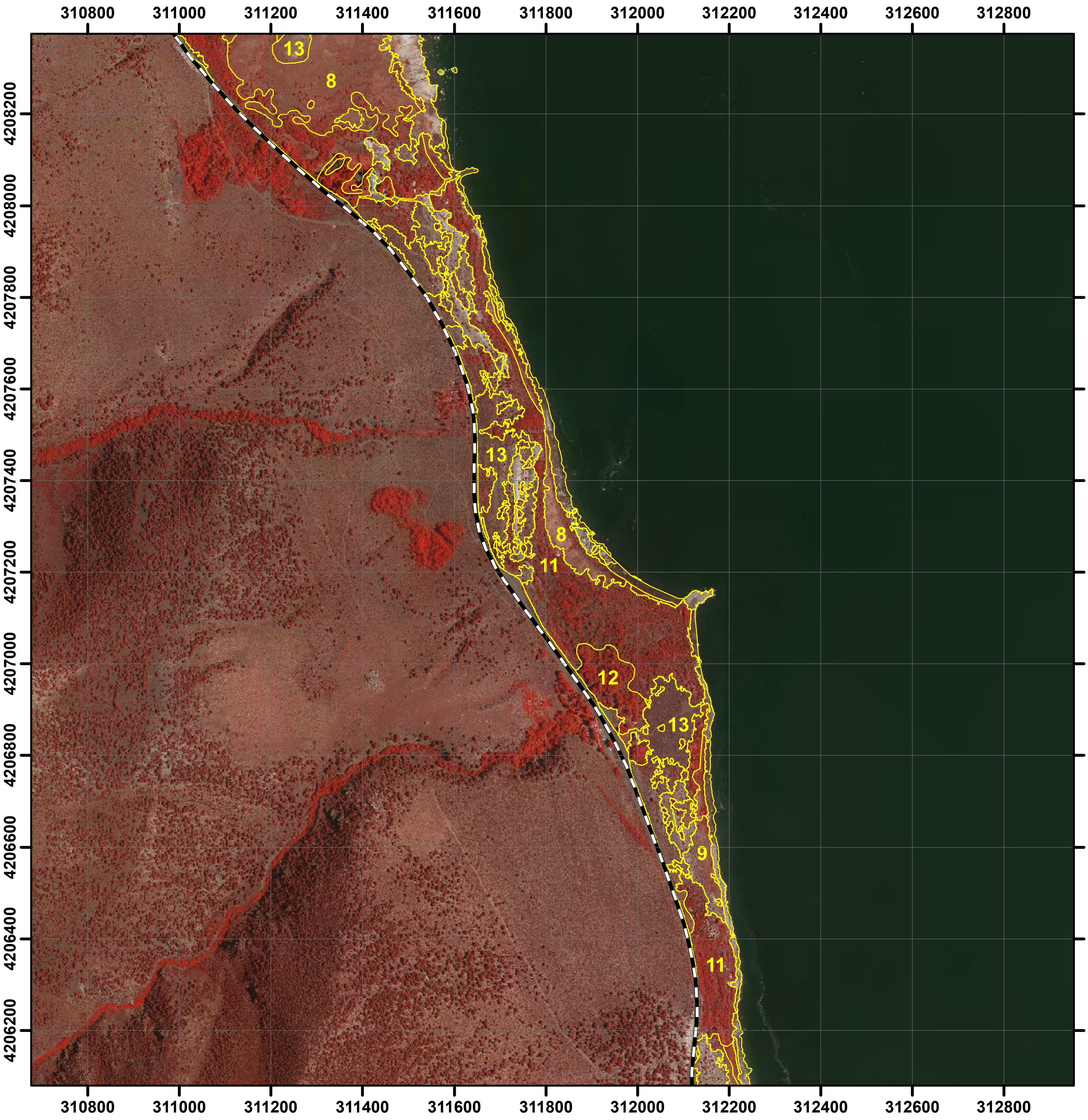
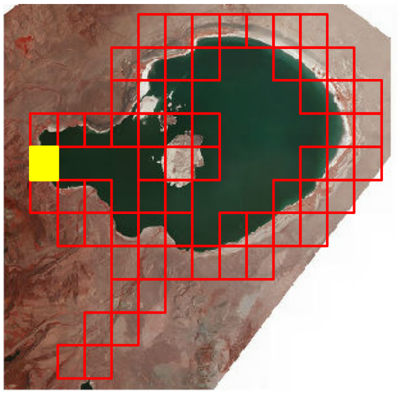
● Photopoint

Note: Great Basin scrub is the combination of upland scrub, rabbitbrush, eolian, and pinyon woodland landtypes delineated in 2014; dry meadow/forb is rabbitbrush/meadow delineated in 2014; unvegetated is the combined area of barren lake bed and streambar delineated in 2014. Photopoints are linked to photographs in APPENDIX C.

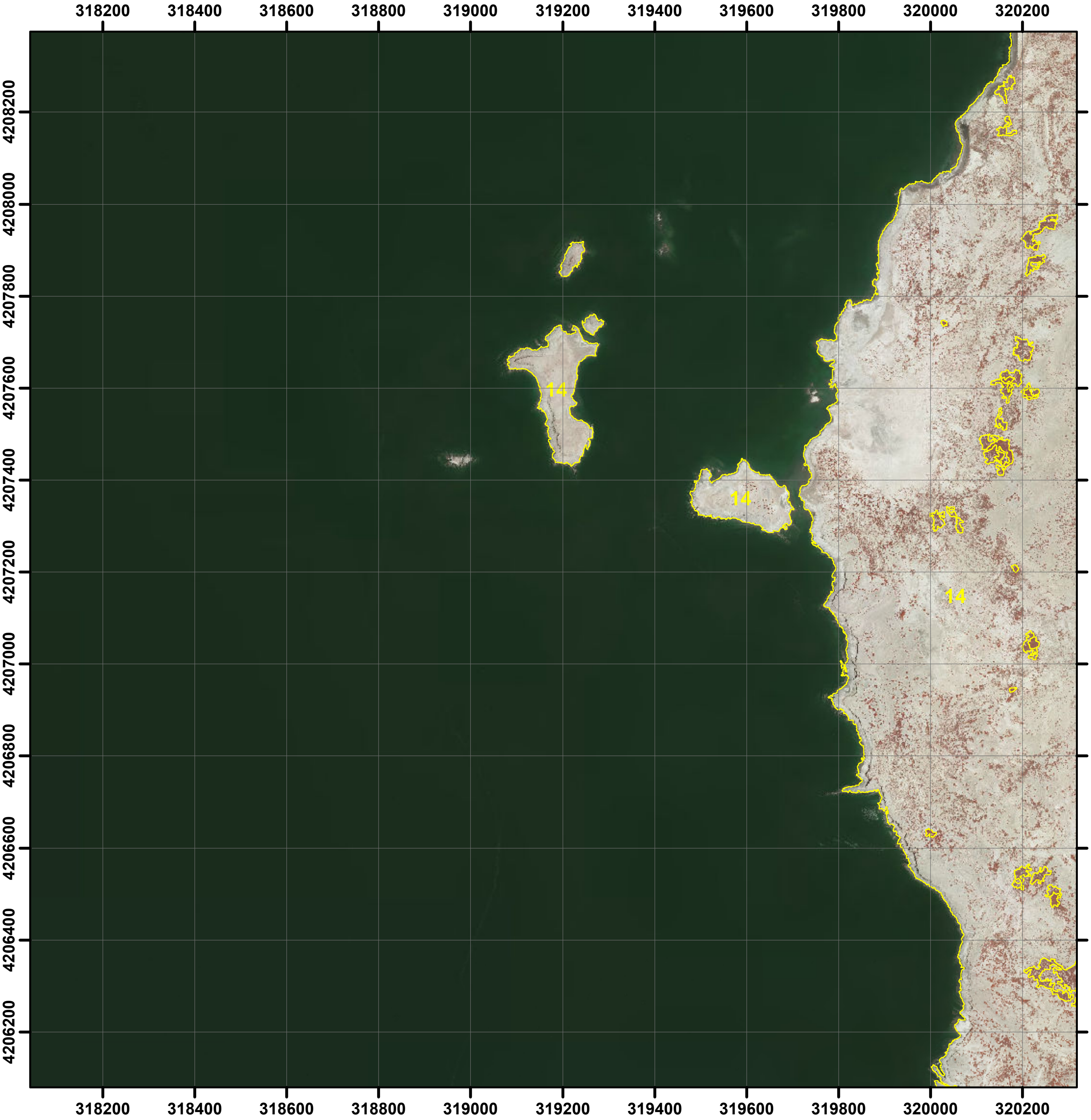


Mono Lake Landtype, 2014 Conditions
Map E1

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made
● Photopoint

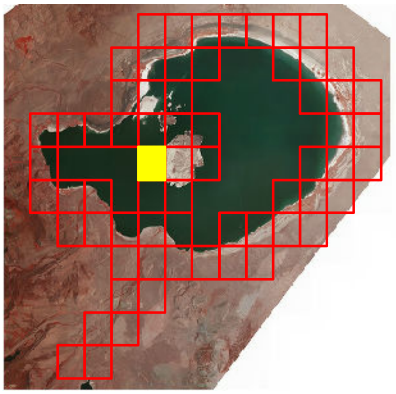


Note: Great Basin scrub is the combination of upland scrub, rabbitbrush, eolian, and pinyon woodland landtypes delineated in 2014; dry meadow/forb is rabbitbrush/meadow delineated in 2014; unvegetated is the combined area of barren lake bed and streambar delineated in 2014. Photopoints are linked to photographs in APPENDIX C.



Mono Lake Landtype, 2014 Conditions

Map E5



1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
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12 = Riparian woodland
13 = Great Basin scrub
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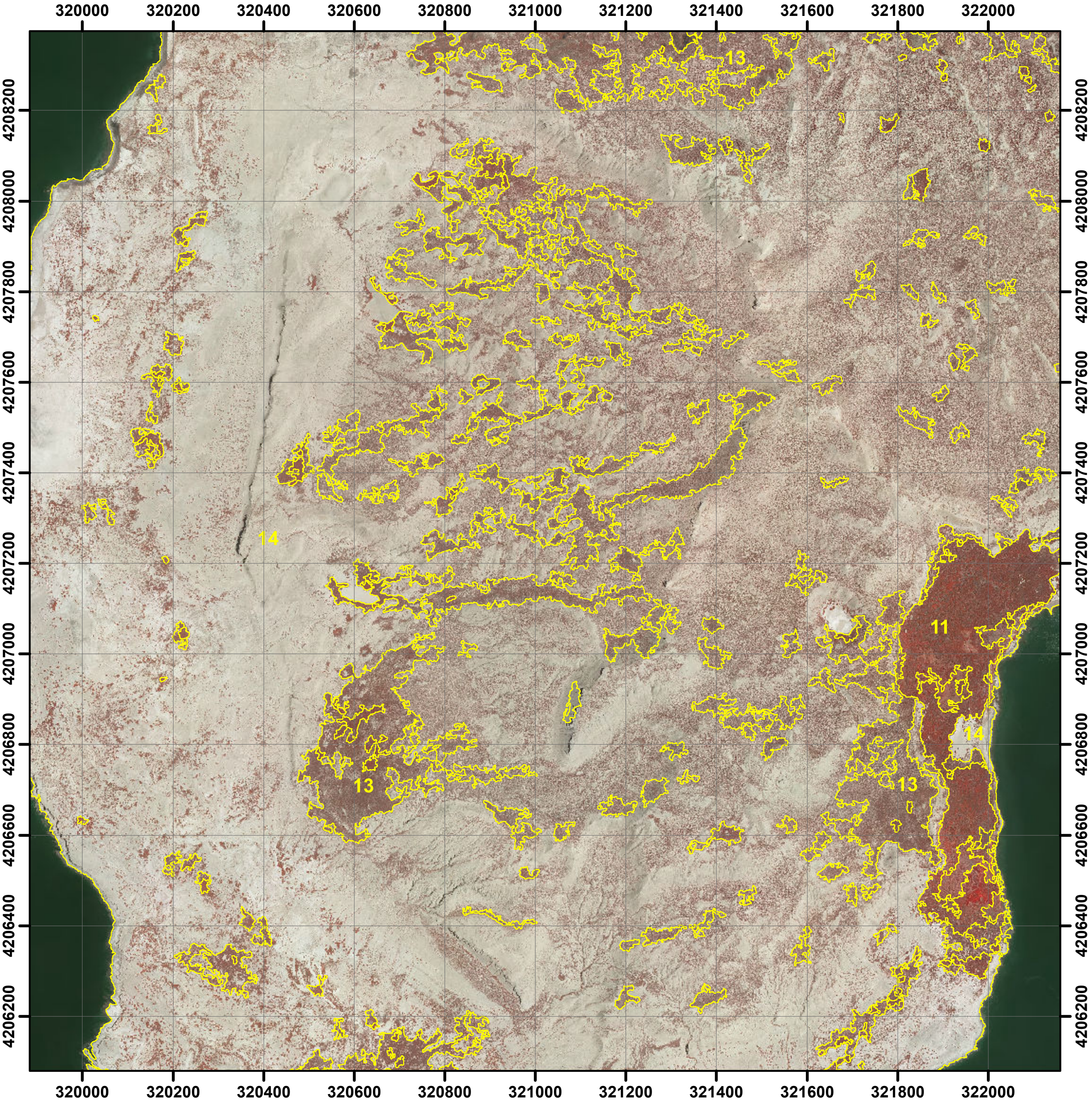
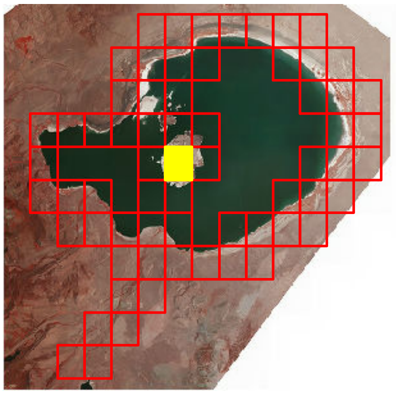
● Photopoint

Note: Great Basin scrub is the combination of upland scrub, rabbitbrush, eolian, and pinyon woodland landtypes delineated in 2014; dry meadow/forb is rabbitbrush/meadow delineated in 2014; unvegetated is the combined area of barren lake bed and streambar delineated in 2014. Photopoints are linked to photographs in APPENDIX C.

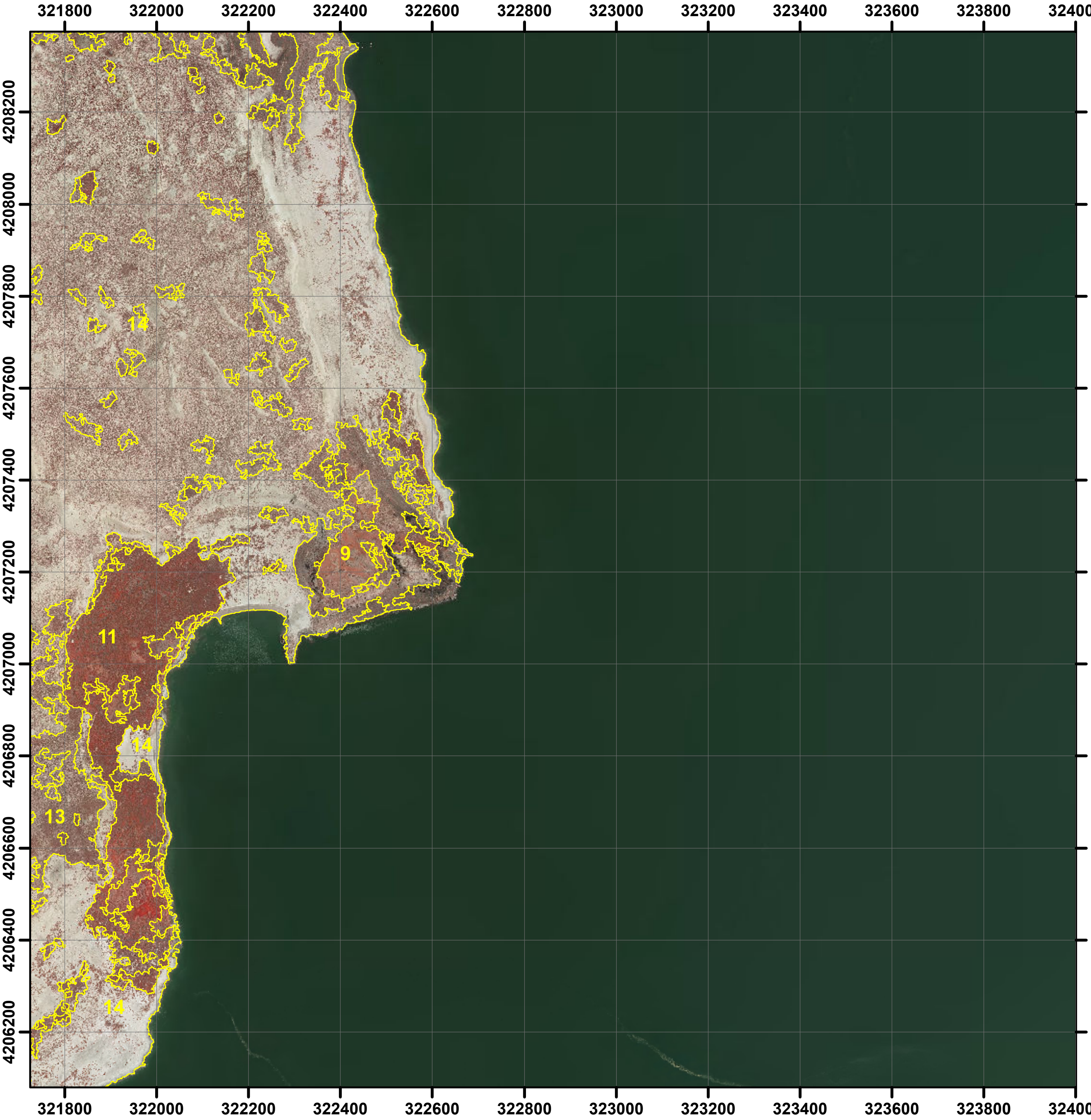


Mono Lake Landtype, 2014 Conditions
Map E6

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made
● Photopoint



Note: Great Basin scrub is the combination of upland scrub, rabbitbrush, eolian, and pinyon woodland landtypes delineated in 2014; dry meadow/forb is rabbitbrush/meadow delineated in 2014; unvegetated is the combined area of barren lake bed and streambar delineated in 2014. Photopoints are linked to photographs in APPENDIX C.

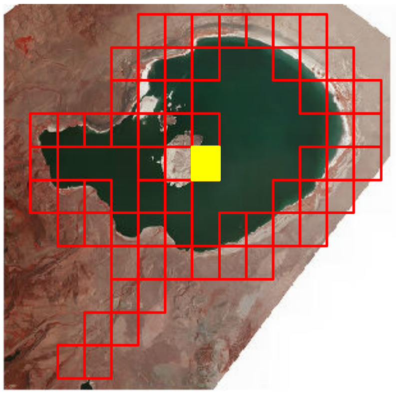


Mono Lake Landtype, 2014 Conditions

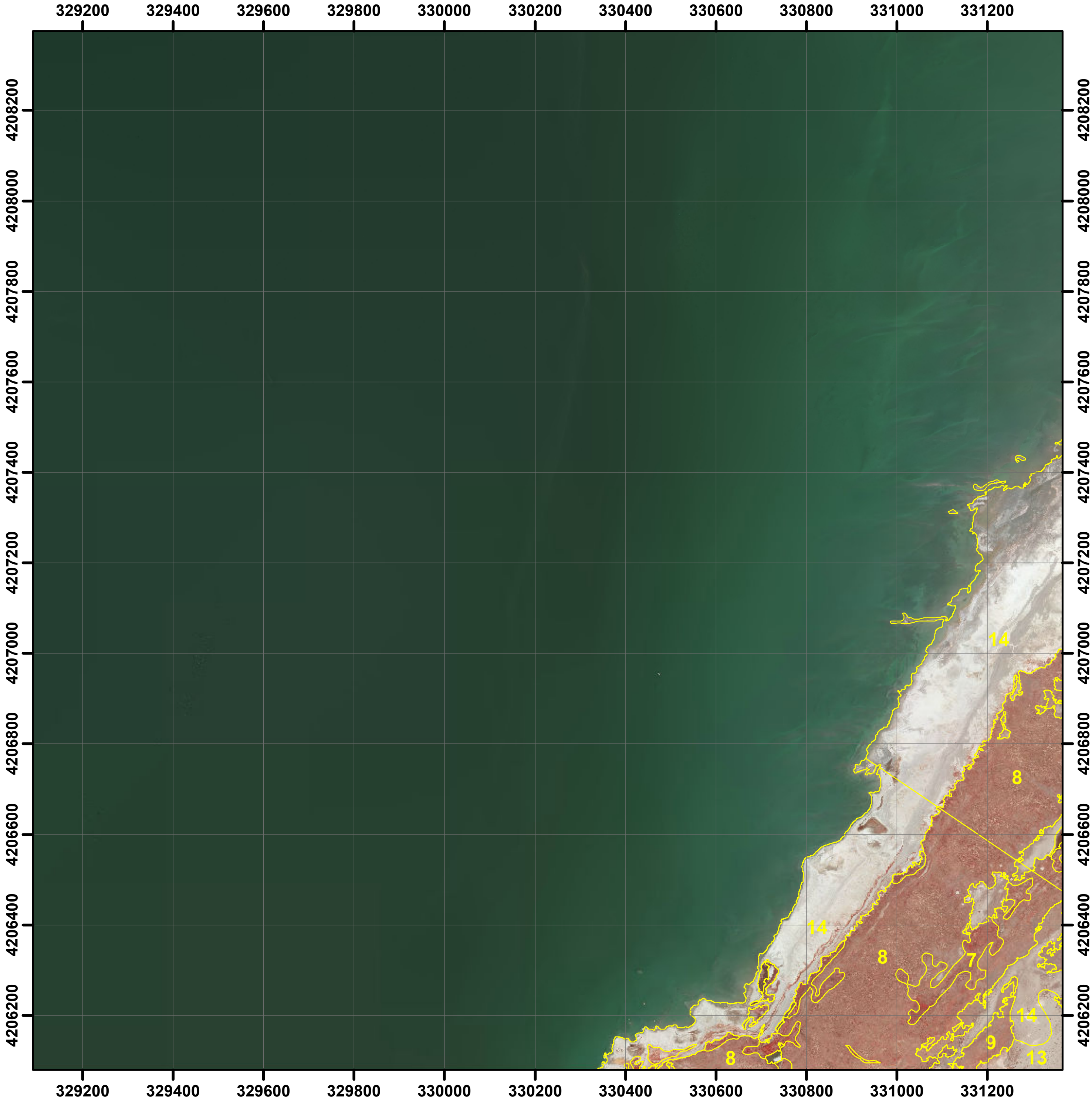
Map E7

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow

9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made
● Photopoint

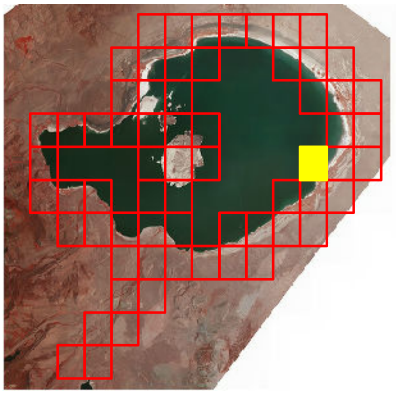


Note: Great Basin scrub is the combination of upland scrub, rabbitbrush, eolian, and pinyon woodland landtypes delineated in 2014; dry meadow/forb is rabbitbrush/meadow delineated in 2014; unvegetated is the combined area of barren lake bed and streambar delineated in 2014. Photopoints are linked to photographs in APPENDIX C.



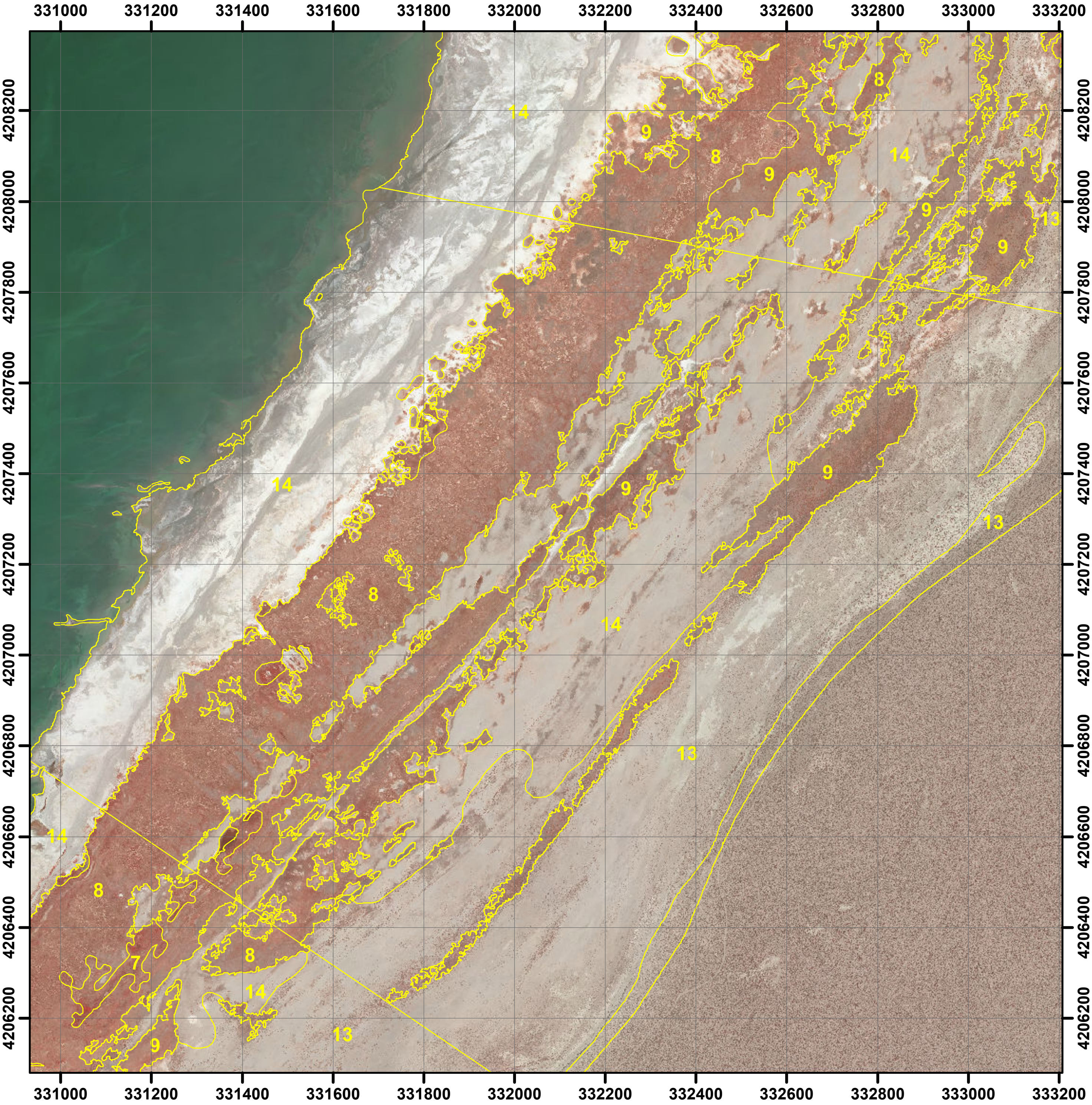
Mono Lake Landtype, 2014 Conditions

Map E11



1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made
● Photopoint

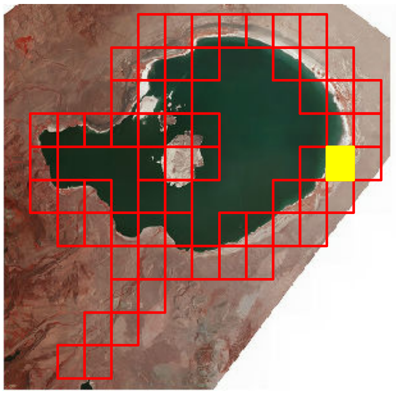
Note: Great Basin scrub is the combination of upland scrub, rabbitbrush, eolian, and pinyon woodland landtypes delineated in 2014; dry meadow/forb is rabbitbrush/meadow delineated in 2014; unvegetated is the combined area of barren lake bed and streambar delineated in 2014. Photopoints are linked to photographs in APPENDIX C.



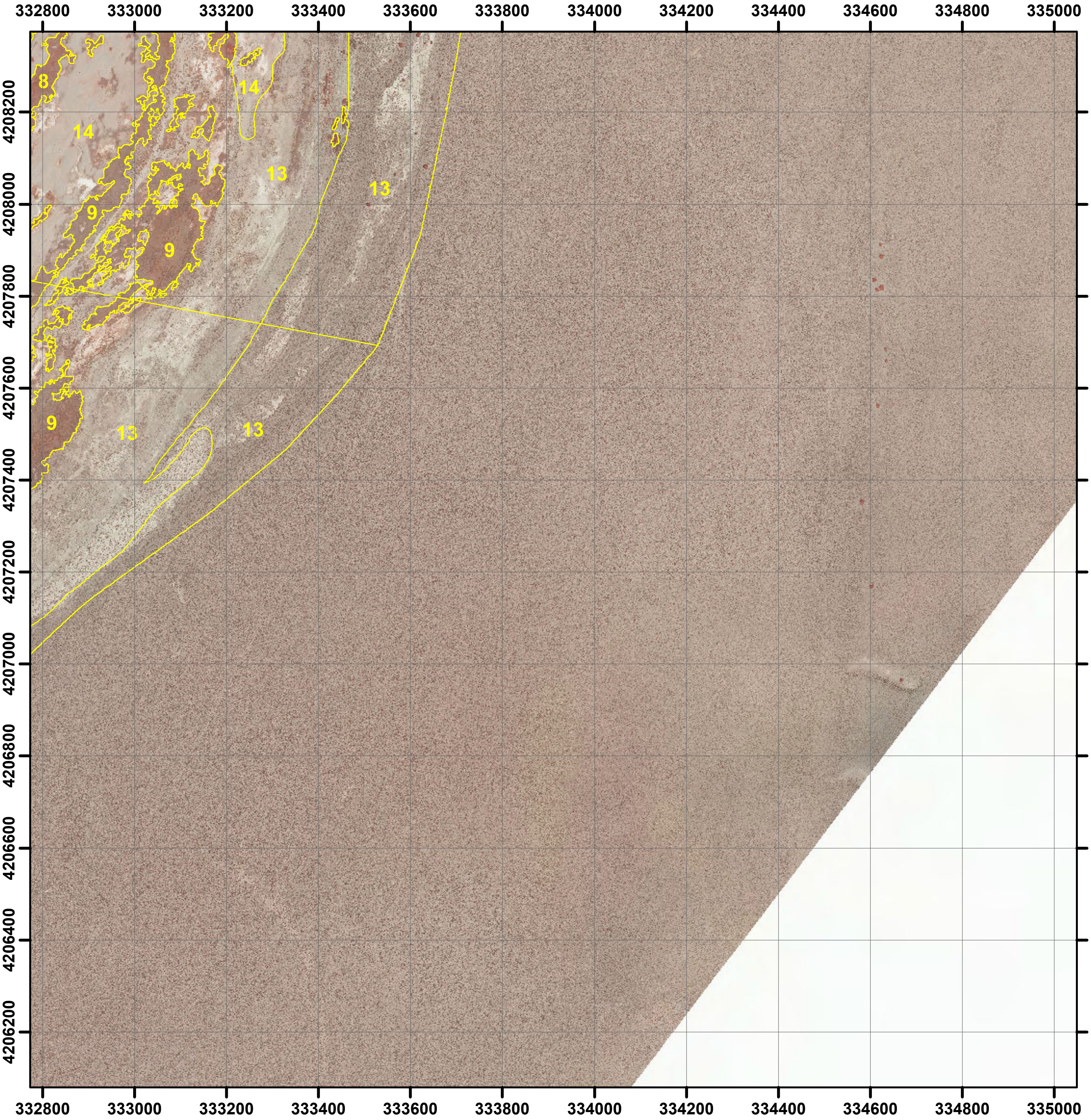
Mono Lake Landtype, 2014 Conditions

Map E12

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made
● Photopoint



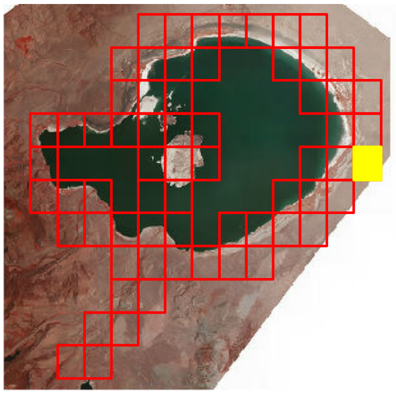
Note: Great Basin scrub is the combination of upland scrub, rabbitbrush, eolian, and pinyon woodland landtypes delineated in 2014; dry meadow/forb is rabbitbrush/meadow delineated in 2014; unvegetated is the combined area of barren lake bed and streambar delineated in 2014. Photopoints are linked to photographs in APPENDIX C.



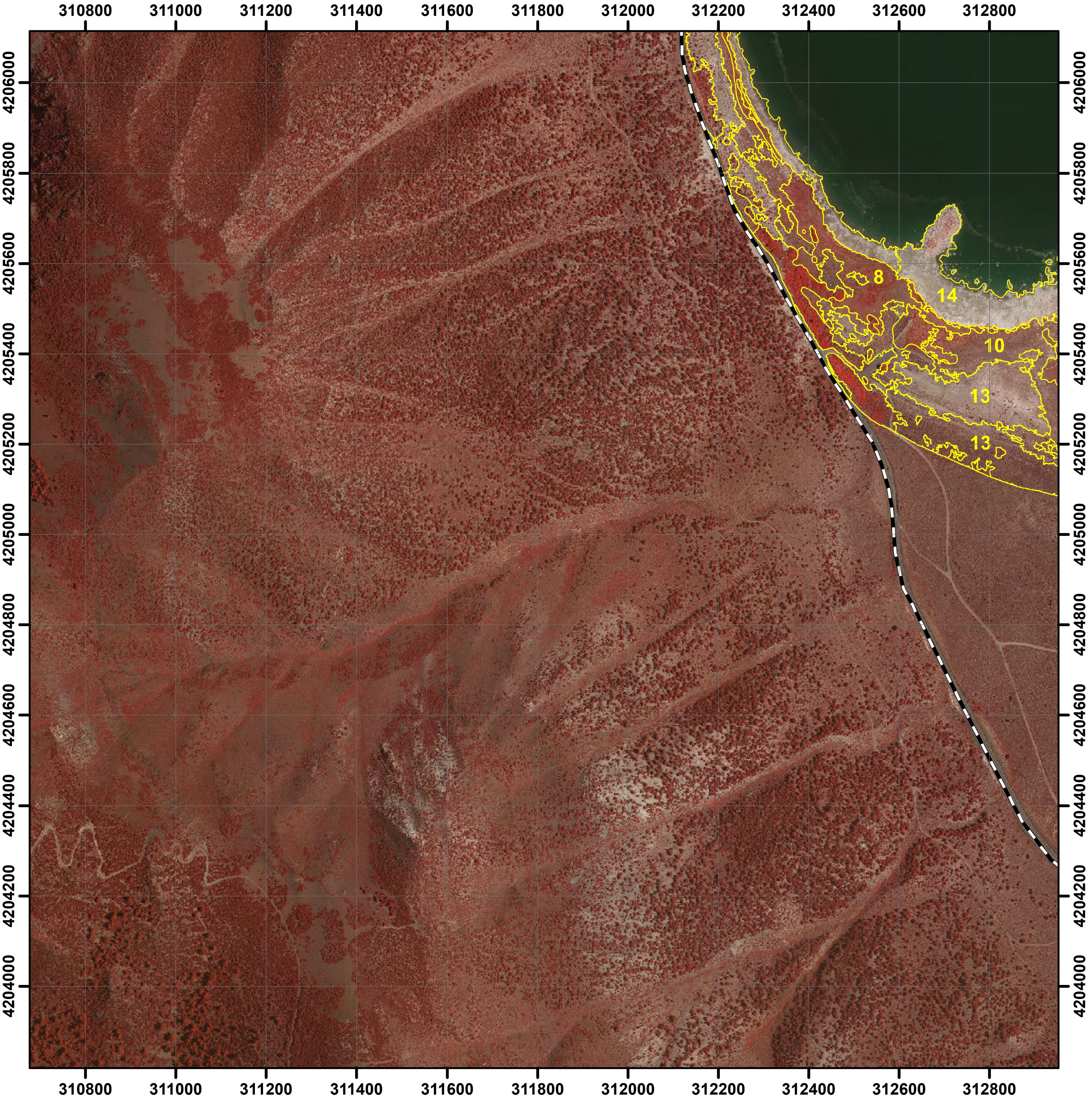
Mono Lake Landtype, 2014 Conditions

Map E13

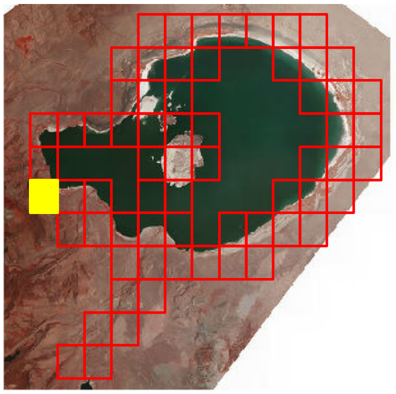
1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made
● Photopoint



Note: Great Basin scrub is the combination of upland scrub, rabbitbrush, eolian, and pinyon woodland landtypes delineated in 2014; dry meadow/forb is rabbitbrush/meadow delineated in 2014; unvegetated is the combined area of barren lake bed and streambar delineated in 2014. Photopoints are linked to photographs in APPENDIX C.

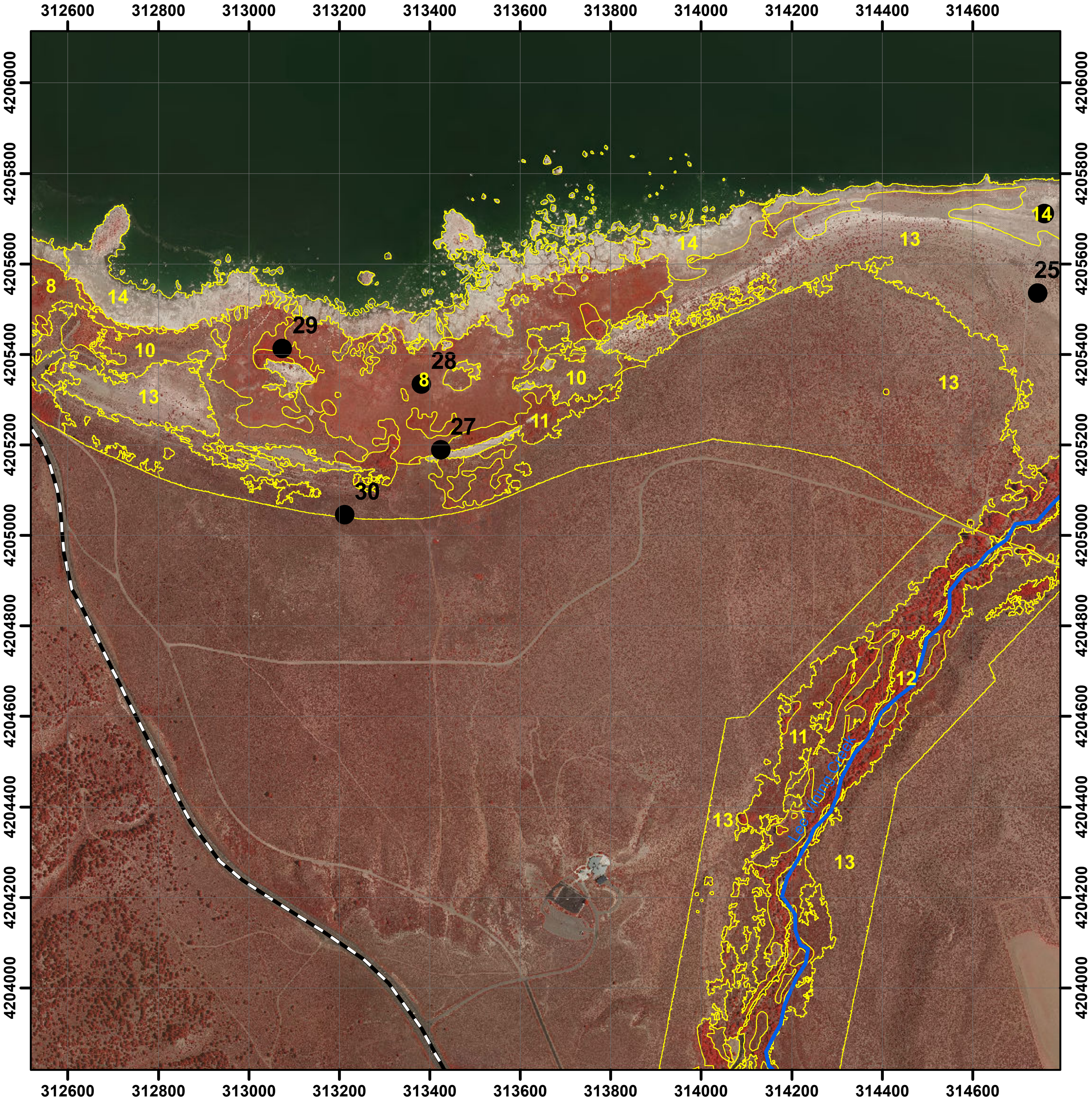


Mono Lake Landtype, 2014 Conditions
Map F1



1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made
● Photopoint

Note: Great Basin scrub is the combination of upland scrub, rabbitbrush, eolian, and pinyon woodland landtypes delineated in 2014; dry meadow/forb is rabbitbrush/meadow delineated in 2014; unvegetated is the combined area of barren lake bed and streambar delineated in 2014. Photopoints are linked to photographs in APPENDIX C.

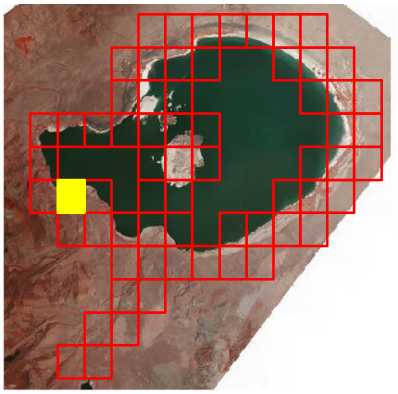


Mono Lake Landtype, 2014 Conditions

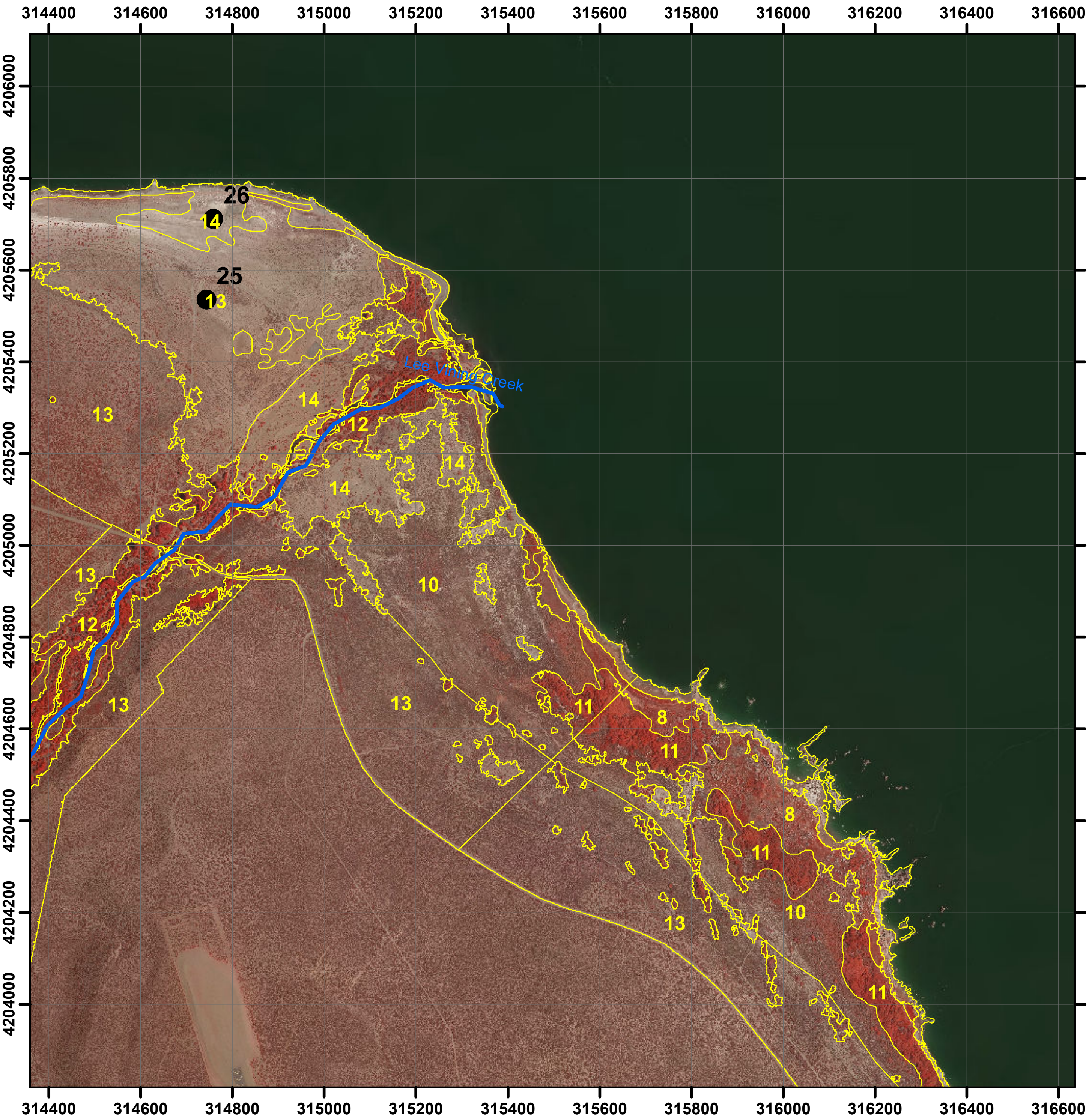
Map F2

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow

9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made
● Photopoint



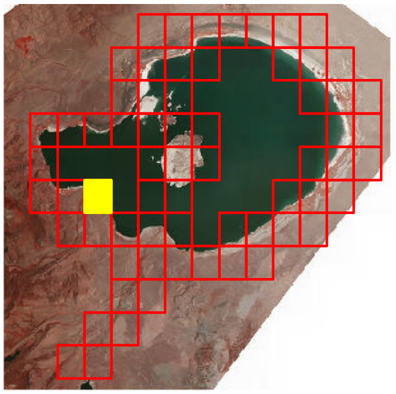
Note: Great Basin scrub is the combination of upland scrub, rabbitbrush, eolian, and pinyon woodland landtypes delineated in 2014; dry meadow/forb is rabbitbrush/meadow delineated in 2014; unvegetated is the combined area of barren lake bed and streambar delineated in 2014. Photopoints are linked to photographs in APPENDIX C.



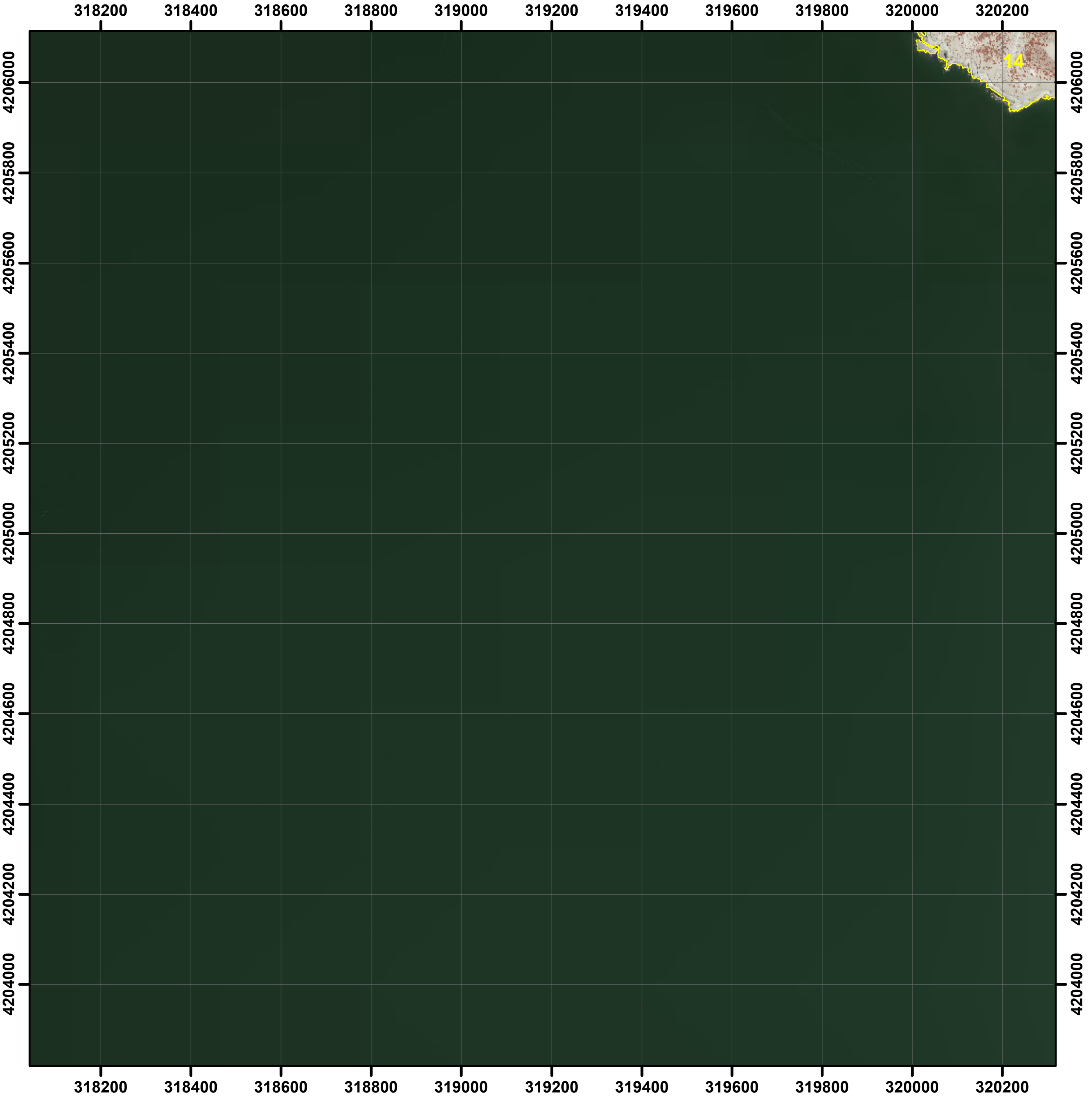
Mono Lake Landtype, 2014 Conditions

Map F3

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made
● Photopoint



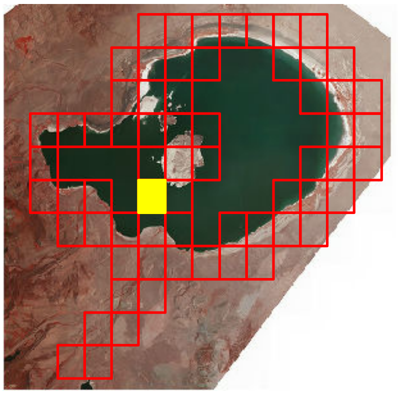
Note: Great Basin scrub is the combination of upland scrub, rabbitbrush, eolian, and pinyon woodland landtypes delineated in 2014; dry meadow/forb is rabbitbrush/meadow delineated in 2014; unvegetated is the combined area of barren lake bed and streambar delineated in 2014. Photopoints are linked to photographs in APPENDIX C.



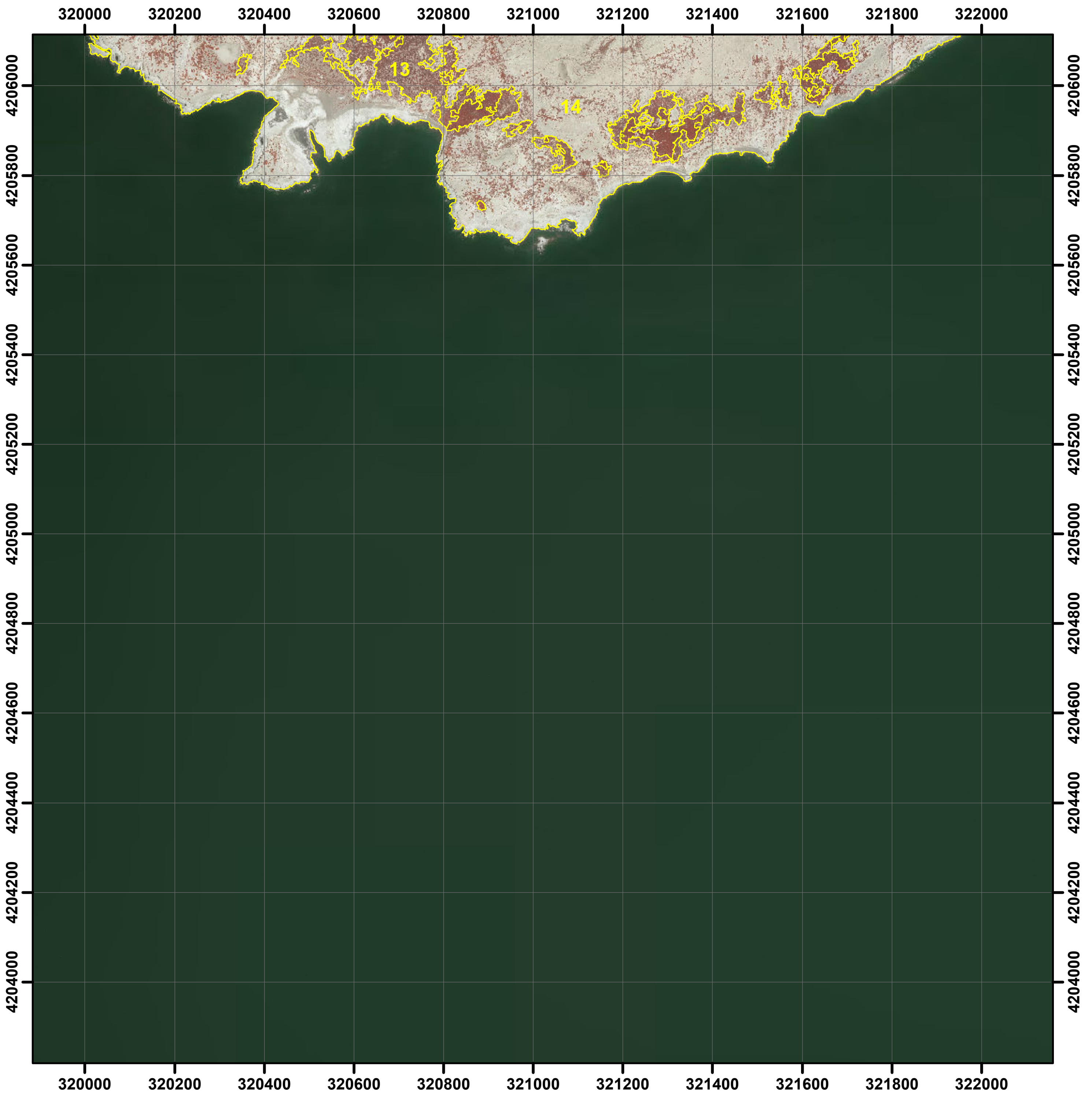
Mono Lake Landtype, 2014 Conditions
Map F5

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow

9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made
● Photopoint

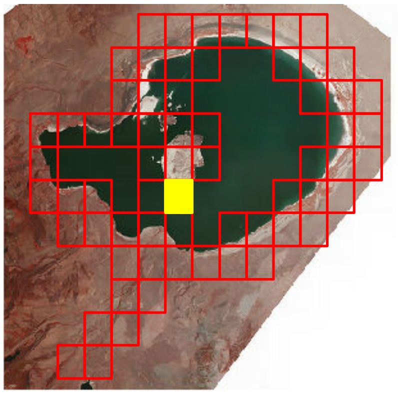


Note: Great Basin scrub is the combination of upland scrub, rabbitbrush, eolian, and pinyon woodland landtypes delineated in 2014; dry meadow/forb is rabbitbrush/meadow delineated in 2014; unvegetated is the combined area of barren lake bed and streambar delineated in 2014. Photopoints are linked to photographs in APPENDIX C.



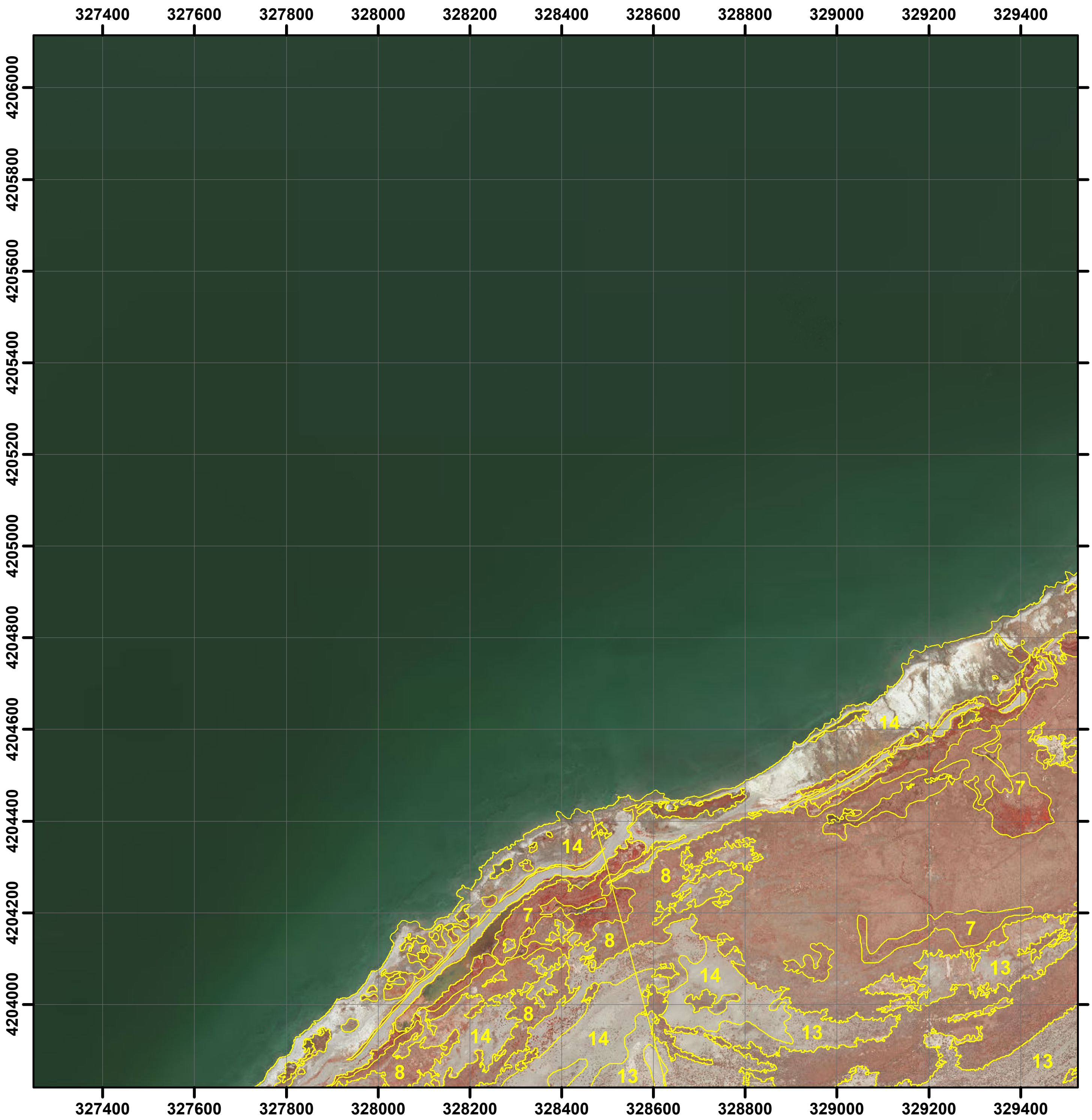
Mono Lake Landtype, 2014 Conditions

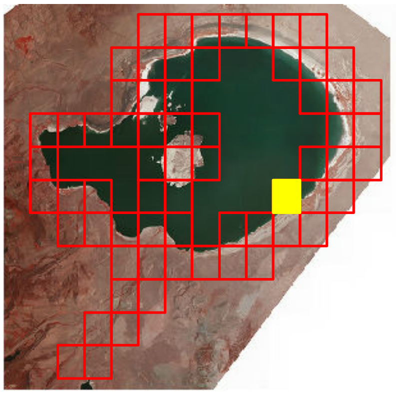
Map F6



1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made
● Photopoint

Note: Great Basin scrub is the combination of upland scrub, rabbitbrush, eolian, and pinyon woodland landtypes delineated in 2014; dry meadow/forb is rabbitbrush/meadow delineated in 2014; unvegetated is the combined area of barren lake bed and streambar delineated in 2014. Photopoints are linked to photographs in APPENDIX C.



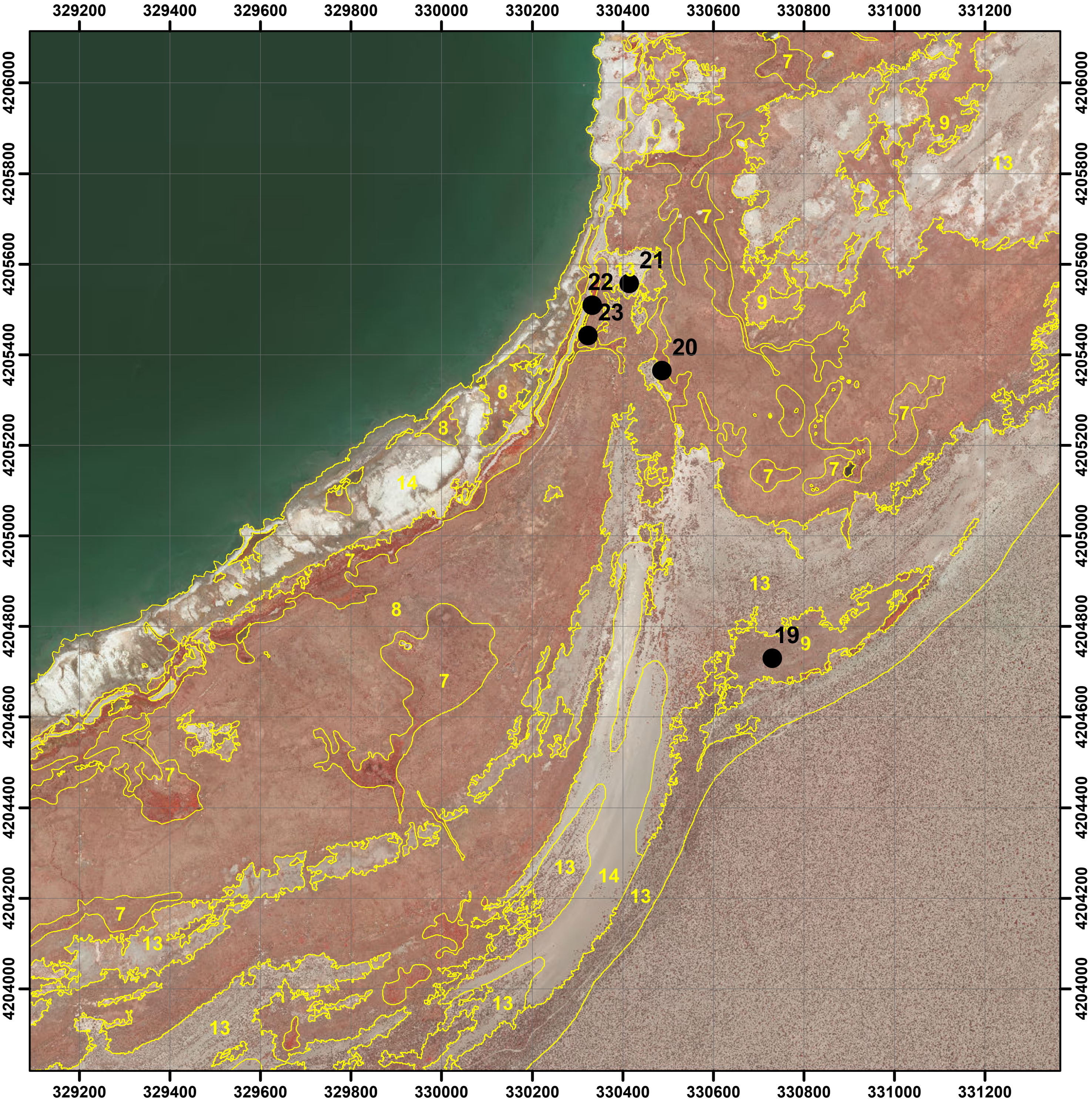


Mono Lake Landtype, 2014 Conditions

Map F10

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made
● Photopoint

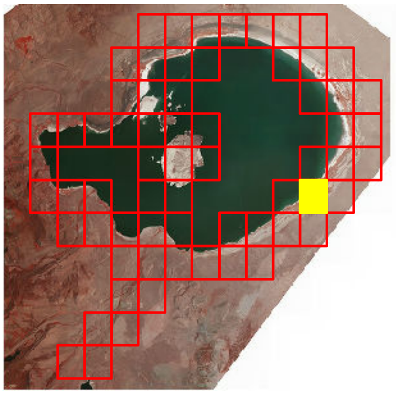
Note: Great Basin scrub is the combination of upland scrub, rabbitbrush, eolian, and pinyon woodland landtypes delineated in 2014; dry meadow/forb is rabbitbrush/meadow delineated in 2014; unvegetated is the combined area of barren lake bed and streambar delineated in 2014. Photopoints are linked to photographs in APPENDIX C.



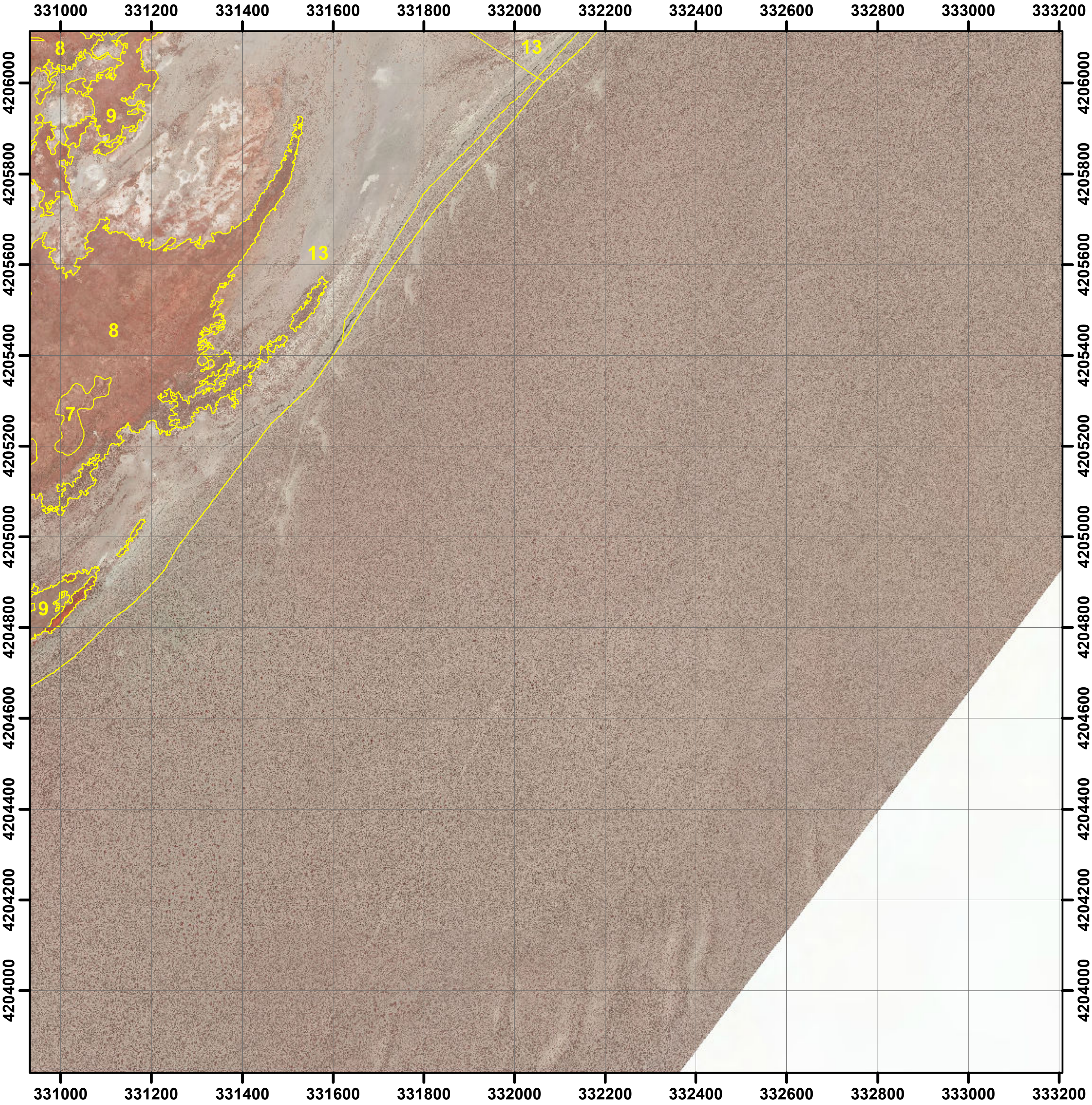
Mono Lake Landtype, 2014 Conditions

Map F11

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made
● Photopoint

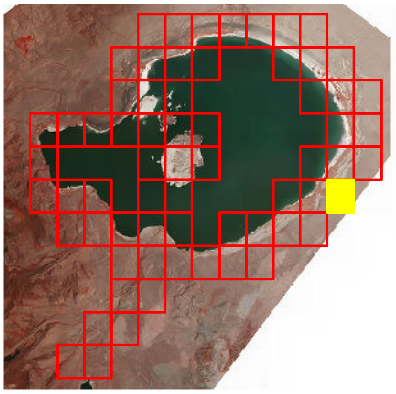


Note: Great Basin scrub is the combination of upland scrub, rabbitbrush, eolian, and pinyon woodland landtypes delineated in 2014; dry meadow/forb is rabbitbrush/meadow delineated in 2014; unvegetated is the combined area of barren lake bed and streambar delineated in 2014. Photopoints are linked to photographs in APPENDIX C.

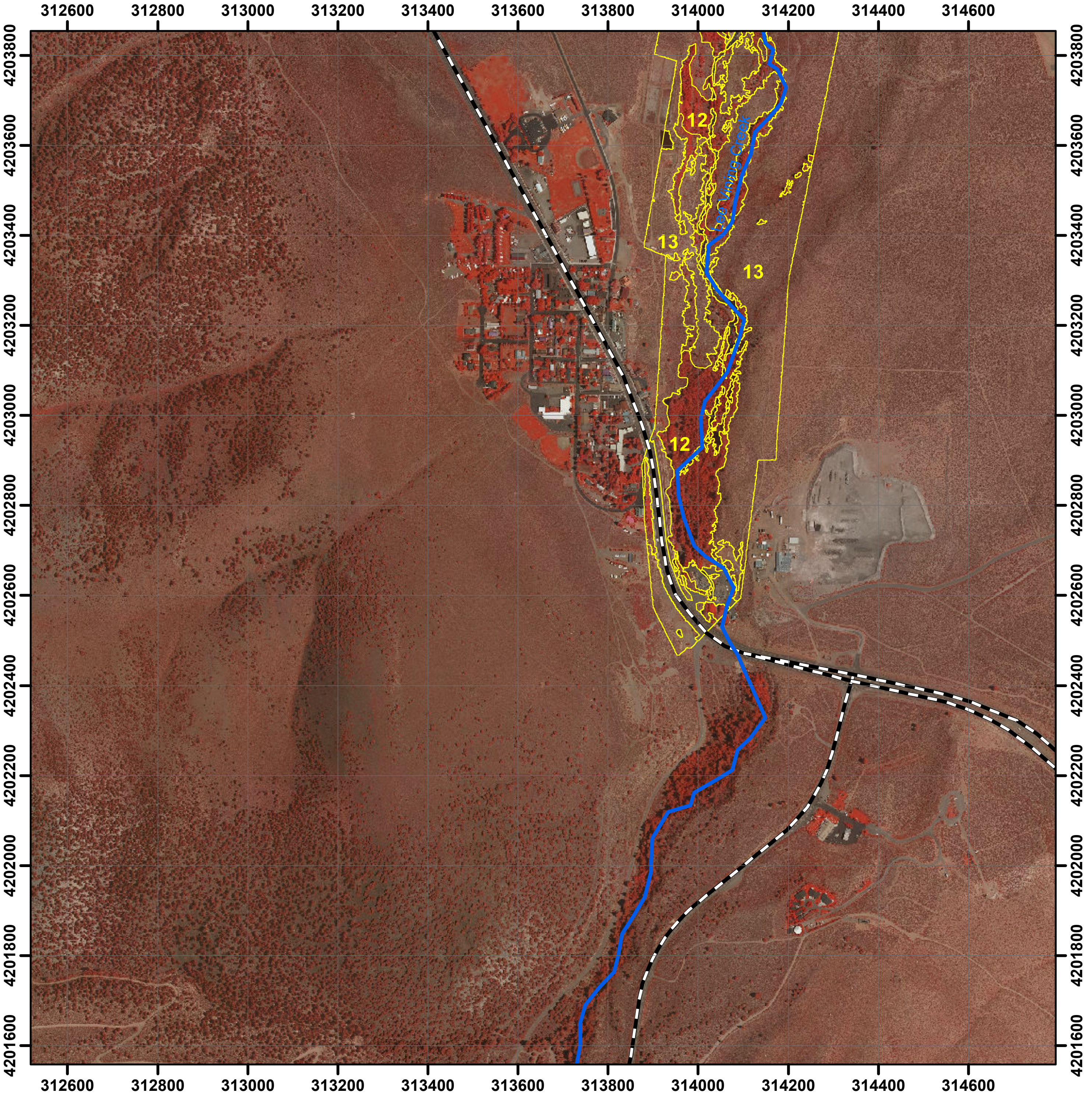


Mono Lake Landtype, 2014 Conditions
Map F12

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made
● Photopoint



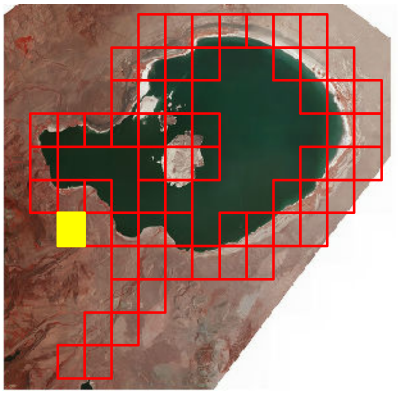
Note: Great Basin scrub is the combination of upland scrub, rabbitbrush, eolian, and pinyon woodland landtypes delineated in 2014; dry meadow/forb is rabbitbrush/meadow delineated in 2014; unvegetated is the combined area of barren lake bed and streambar delineated in 2014. Photopoints are linked to photographs in APPENDIX C.



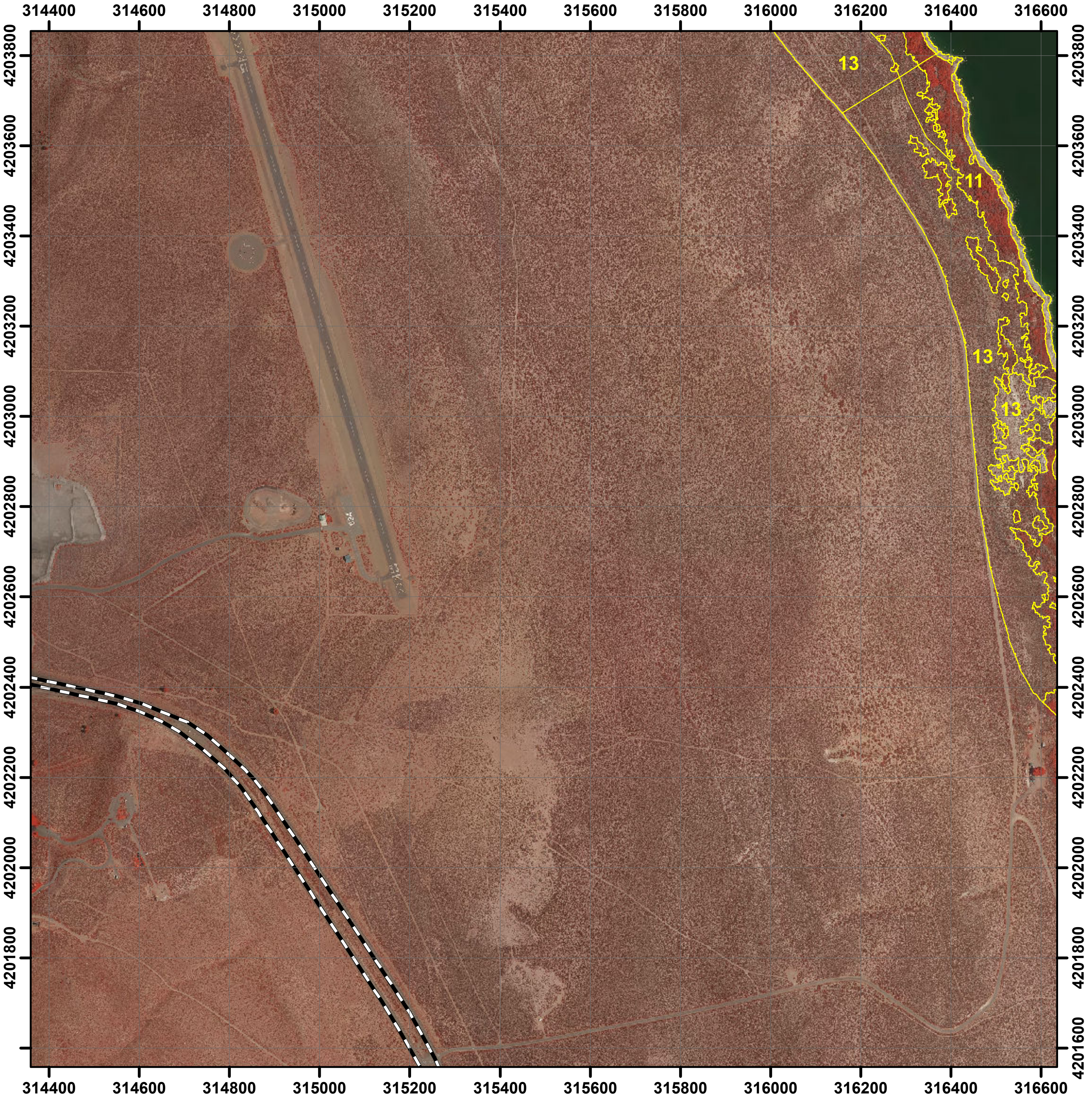
Mono Lake Landtype, 2014 Conditions

Map G2

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made
● Photopoint



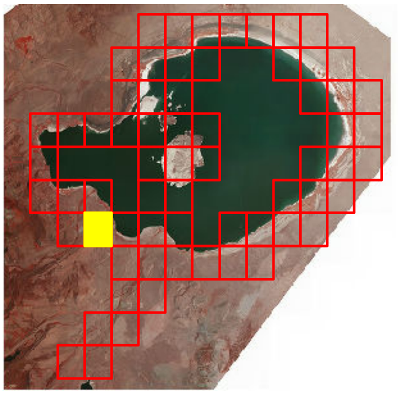
Note: Great Basin scrub is the combination of upland scrub, rabbitbrush, eolian, and pinyon woodland landtypes delineated in 2014; dry meadow/forb is rabbitbrush/meadow delineated in 2014; unvegetated is the combined area of barren lake bed and streambar delineated in 2014. Photopoints are linked to photographs in APPENDIX C.



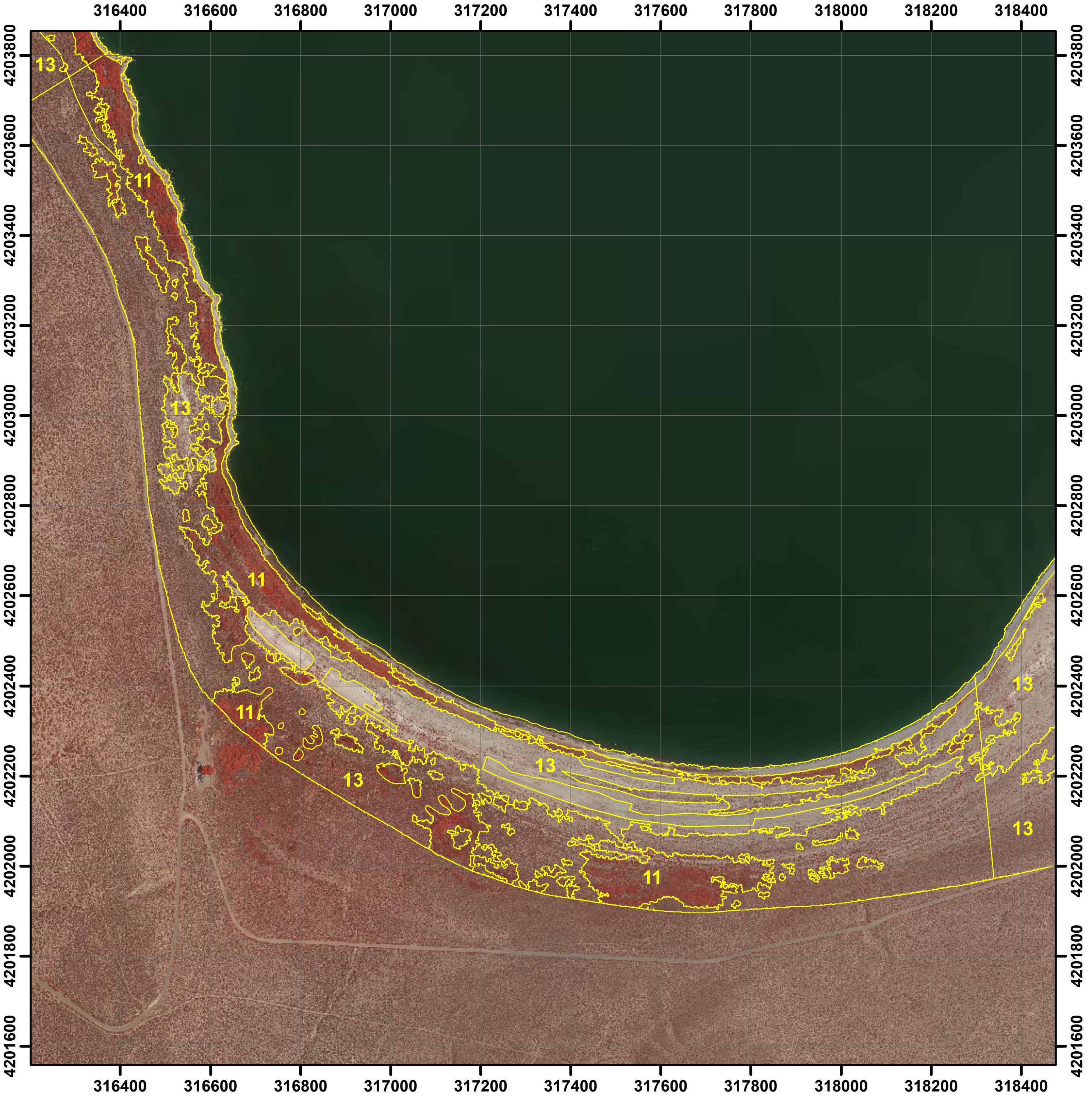
Mono Lake Landtype, 2014 Conditions

Map G3

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made
● Photopoint

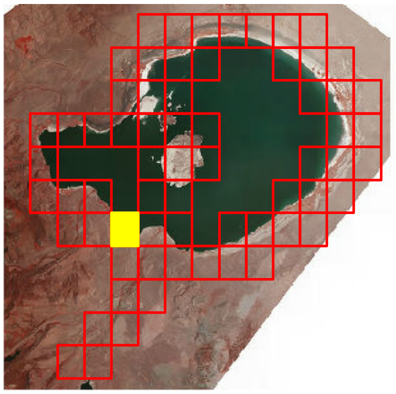


Note: Great Basin scrub is the combination of upland scrub, rabbitbrush, eolian, and pinyon woodland landtypes delineated in 2014; dry meadow/forb is rabbitbrush/meadow delineated in 2014; unvegetated is the combined area of barren lake bed and streambar delineated in 2014. Photopoints are linked to photographs in APPENDIX C.



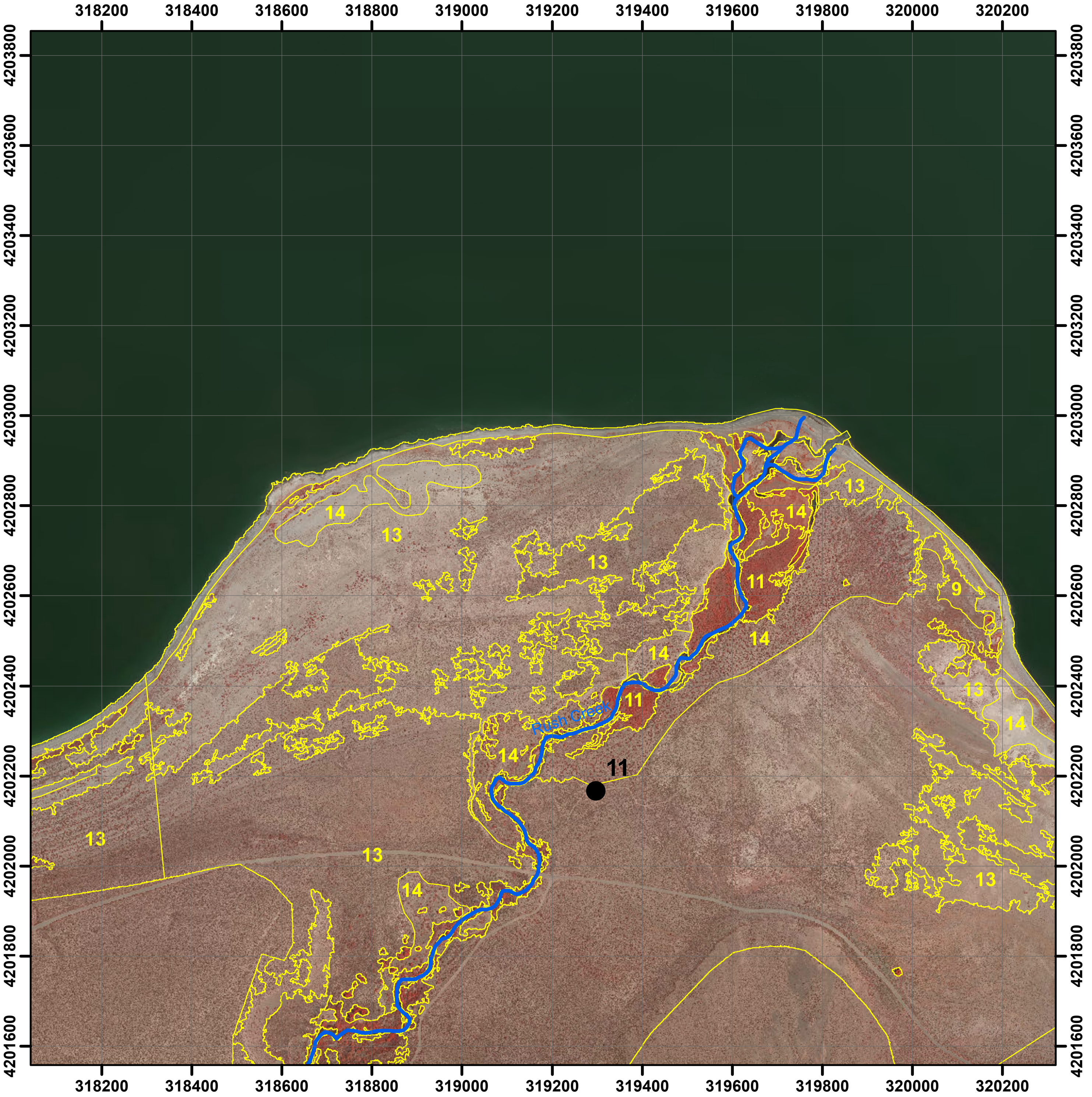
Mono Lake Landtype, 2014 Conditions

Map G4



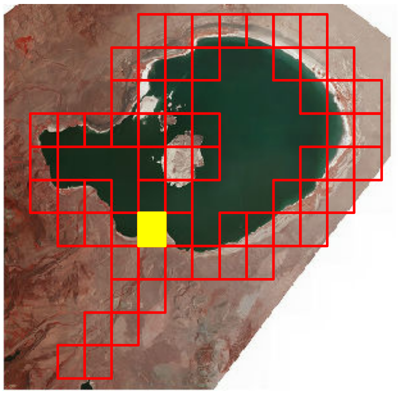
1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made
● Photopoint

Note: Great Basin scrub is the combination of upland scrub, rabbitbrush, eolian, and pinyon woodland landtypes delineated in 2014; dry meadow/forb is rabbitbrush/meadow delineated in 2014; unvegetated is the combined area of barren lake bed and streambar delineated in 2014. Photopoints are linked to photographs in APPENDIX C.

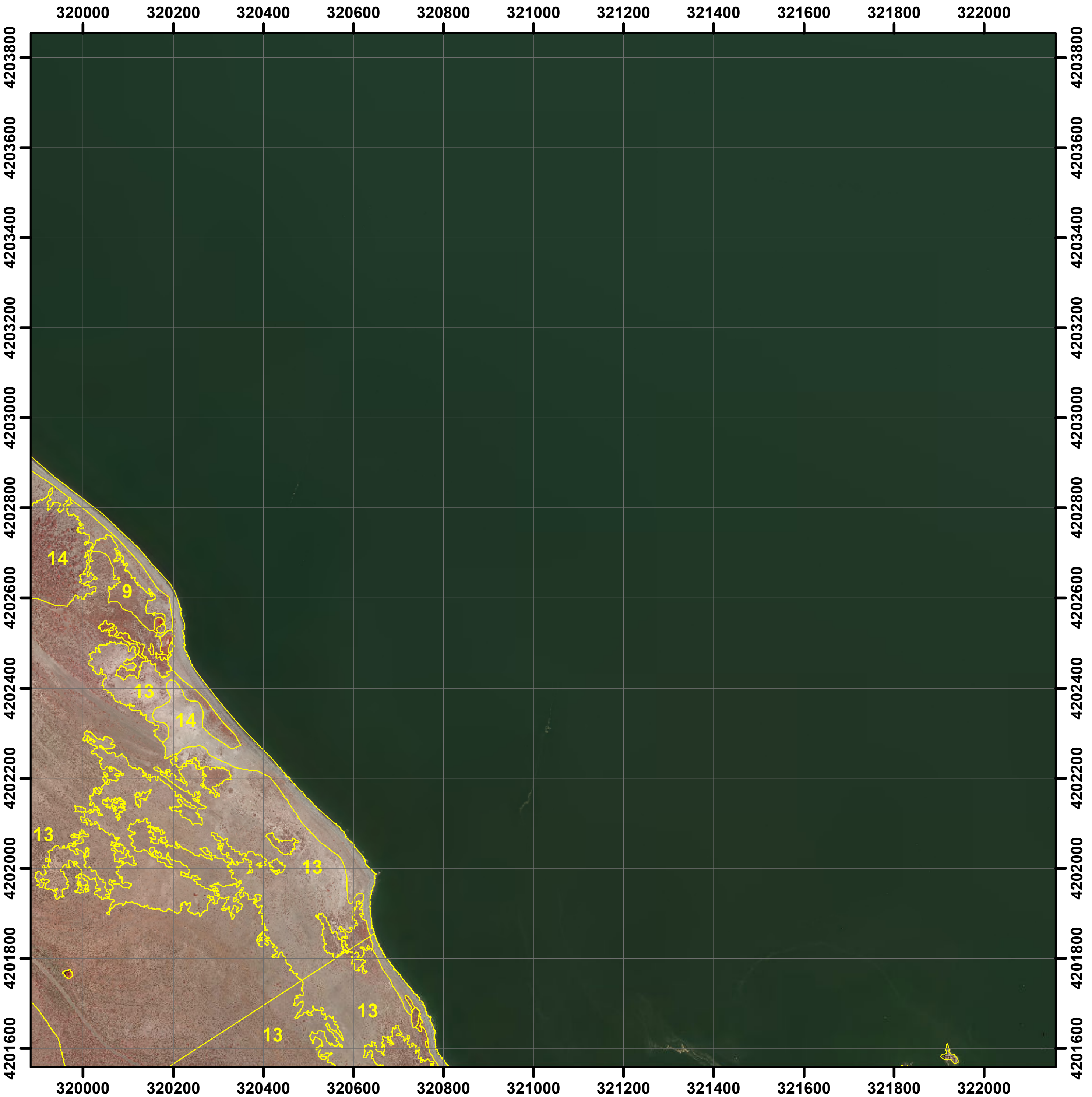


Mono Lake Landtype, 2014 Conditions
Map G5

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made
● Photopoint



Note: Great Basin scrub is the combination of upland scrub, rabbitbrush, eolian, and pinyon woodland landtypes delineated in 2014; dry meadow/forb is rabbitbrush/meadow delineated in 2014; unvegetated is the combined area of barren lake bed and streambar delineated in 2014. Photopoints are linked to photographs in APPENDIX C.

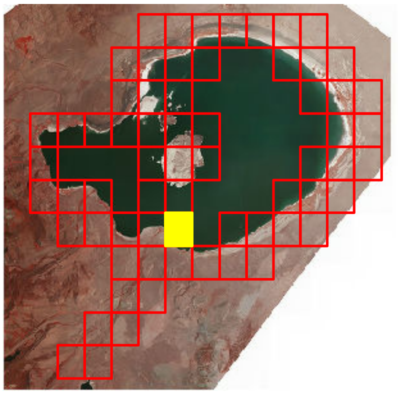


Mono Lake Landtype, 2014 Conditions

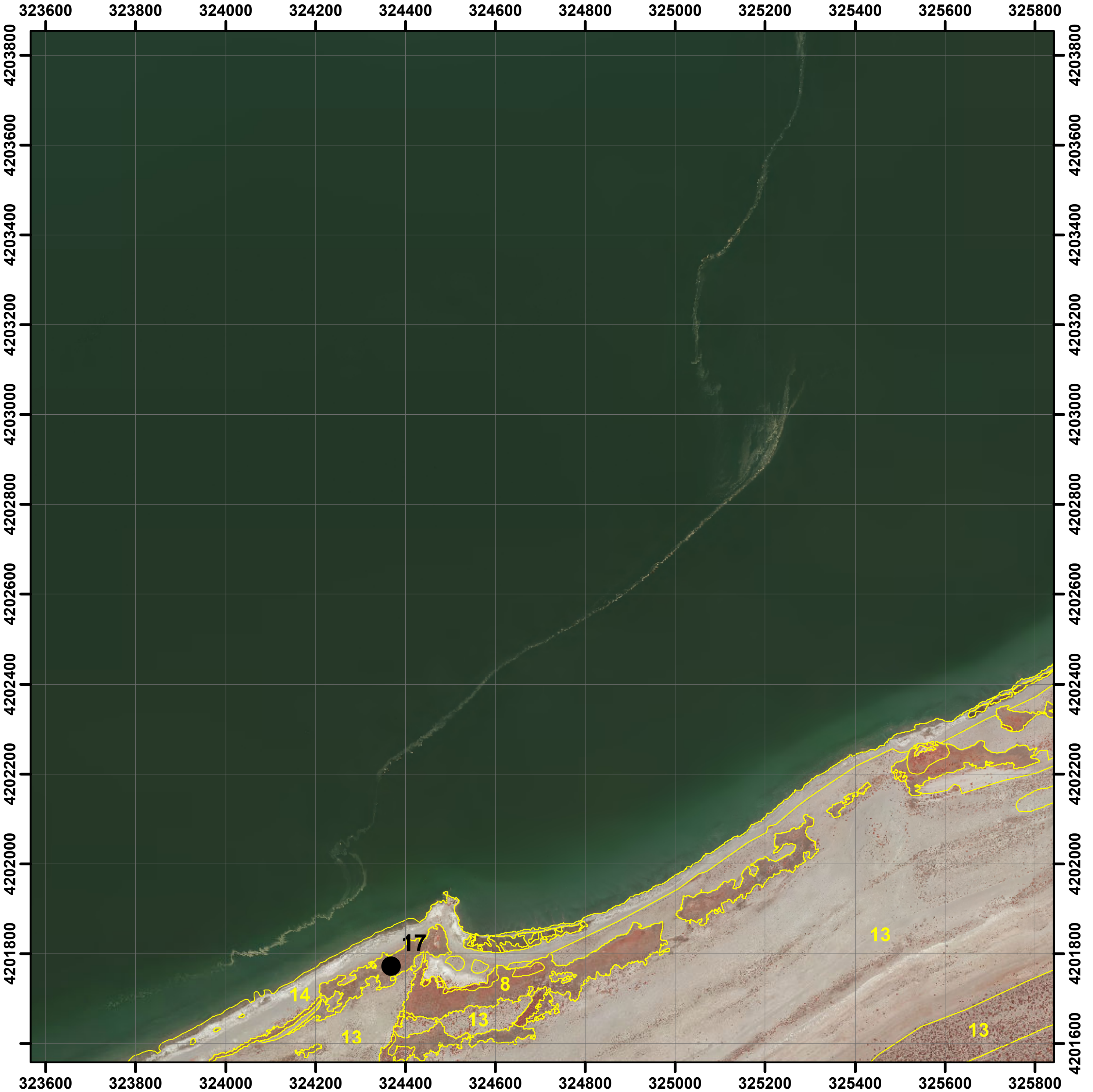
Map G6

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow

9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made
● Photopoint



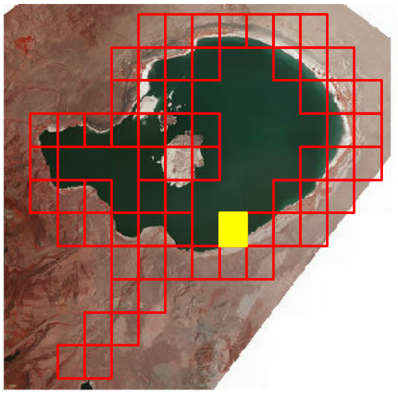
Note: Great Basin scrub is the combination of upland scrub, rabbitbrush, eolian, and pinyon woodland landtypes delineated in 2014; dry meadow/forb is rabbitbrush/meadow delineated in 2014; unvegetated is the combined area of barren lake bed and streambar delineated in 2014. Photopoints are linked to photographs in APPENDIX C.



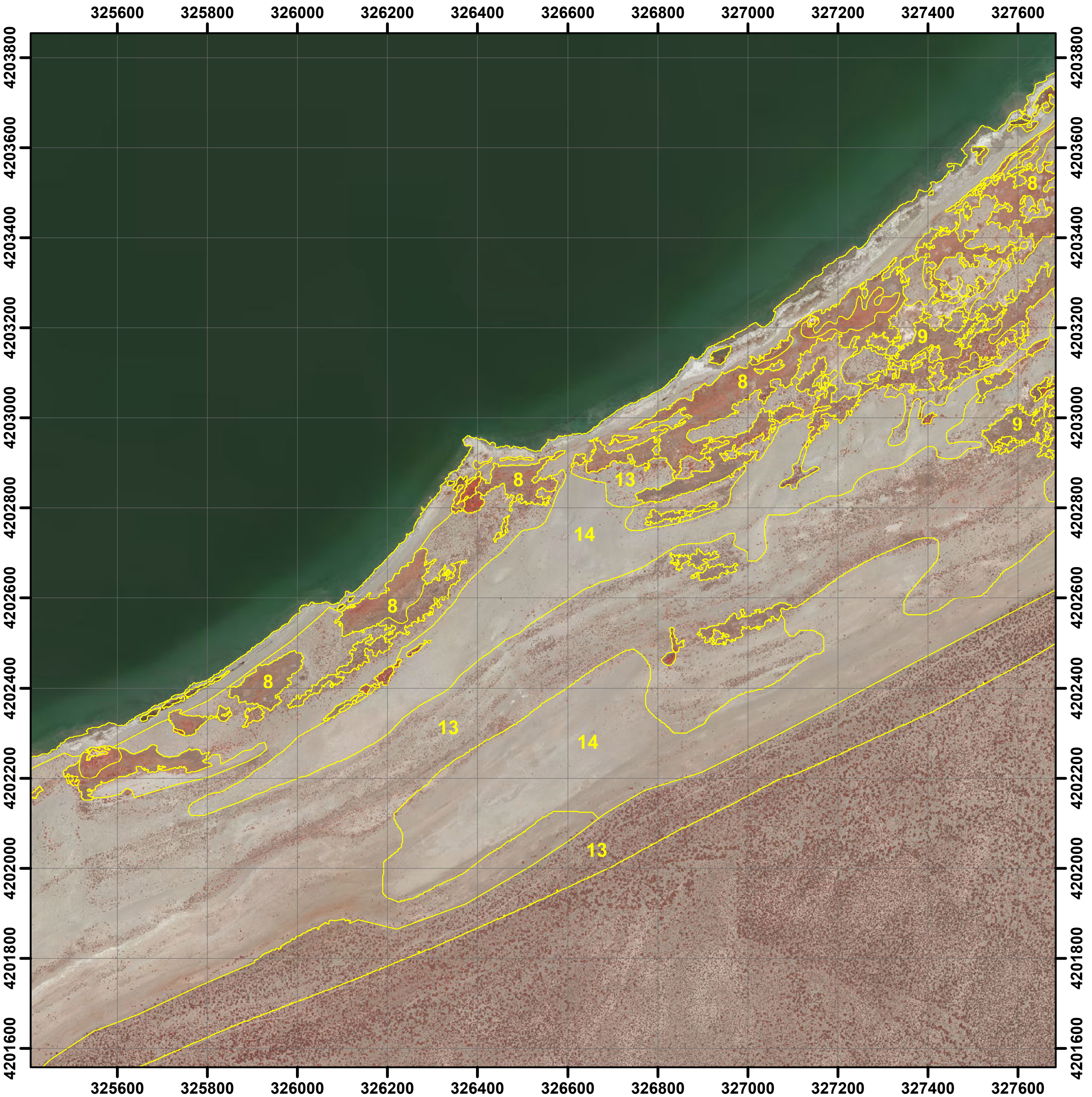
Mono Lake Landtype, 2014 Conditions

Map G8

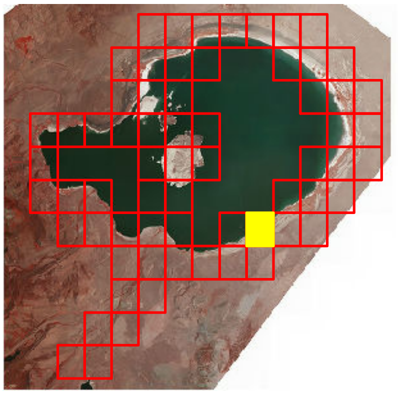
1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made
● Photopoint



Note: Great Basin scrub is the combination of upland scrub, rabbitbrush, eolian, and pinyon woodland landtypes delineated in 2014; dry meadow/forb is rabbitbrush/meadow delineated in 2014; unvegetated is the combined area of barren lake bed and streambar delineated in 2014. Photopoints are linked to photographs in APPENDIX C.

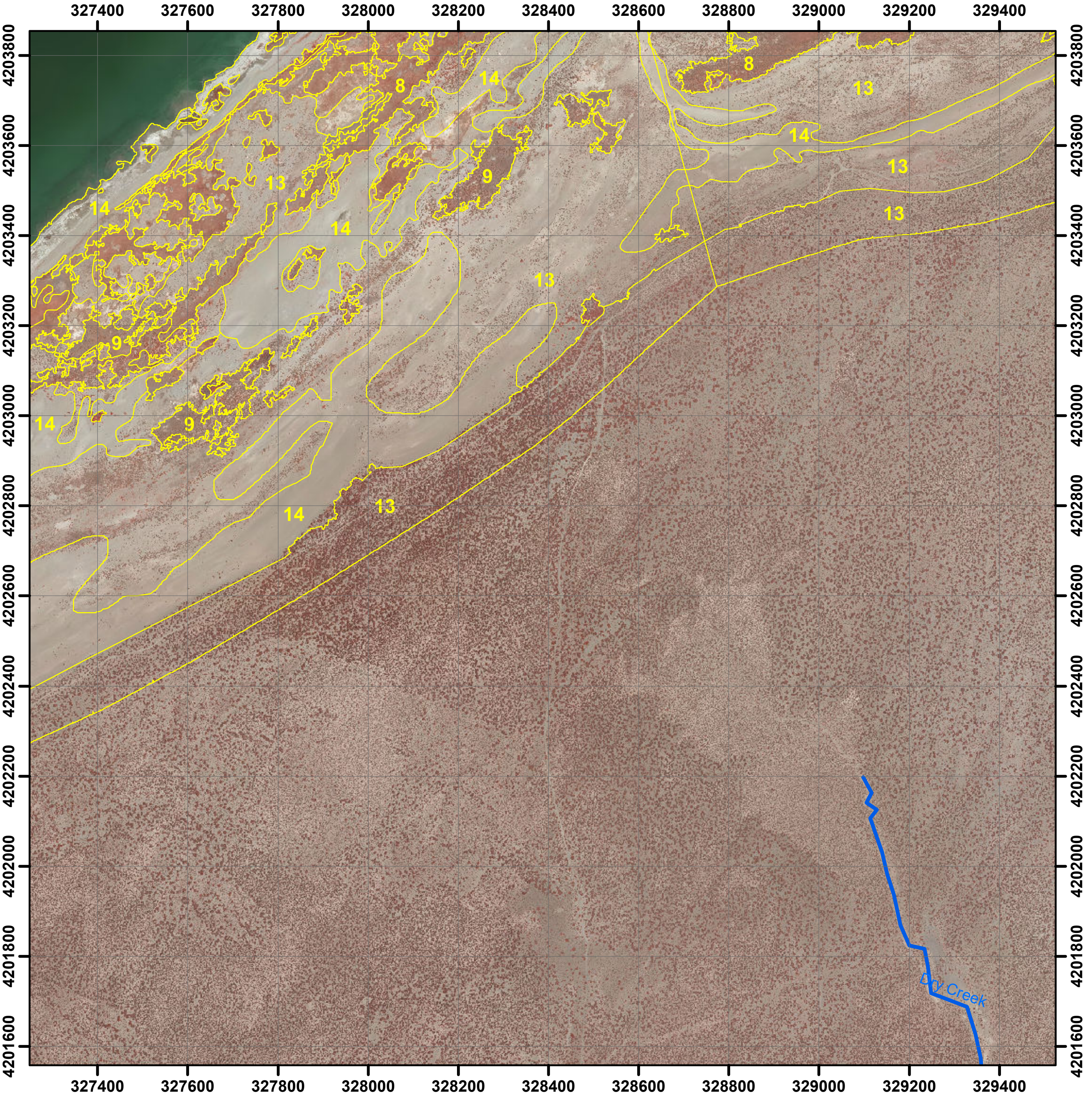


Mono Lake Landtype, 2014 Conditions
Map G9



1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made
● Photopoint

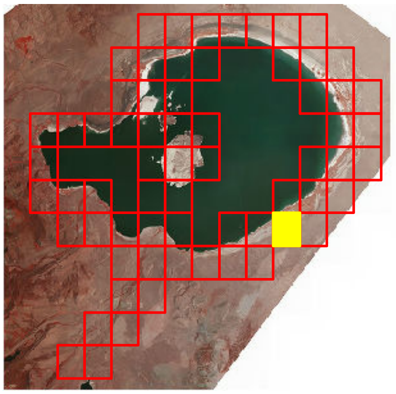
Note: Great Basin scrub is the combination of upland scrub, rabbitbrush, eolian, and pinyon woodland landtypes delineated in 2014; dry meadow/forb is rabbitbrush/meadow delineated in 2014; unvegetated is the combined area of barren lake bed and streambar delineated in 2014. Photopoints are linked to photographs in APPENDIX C.



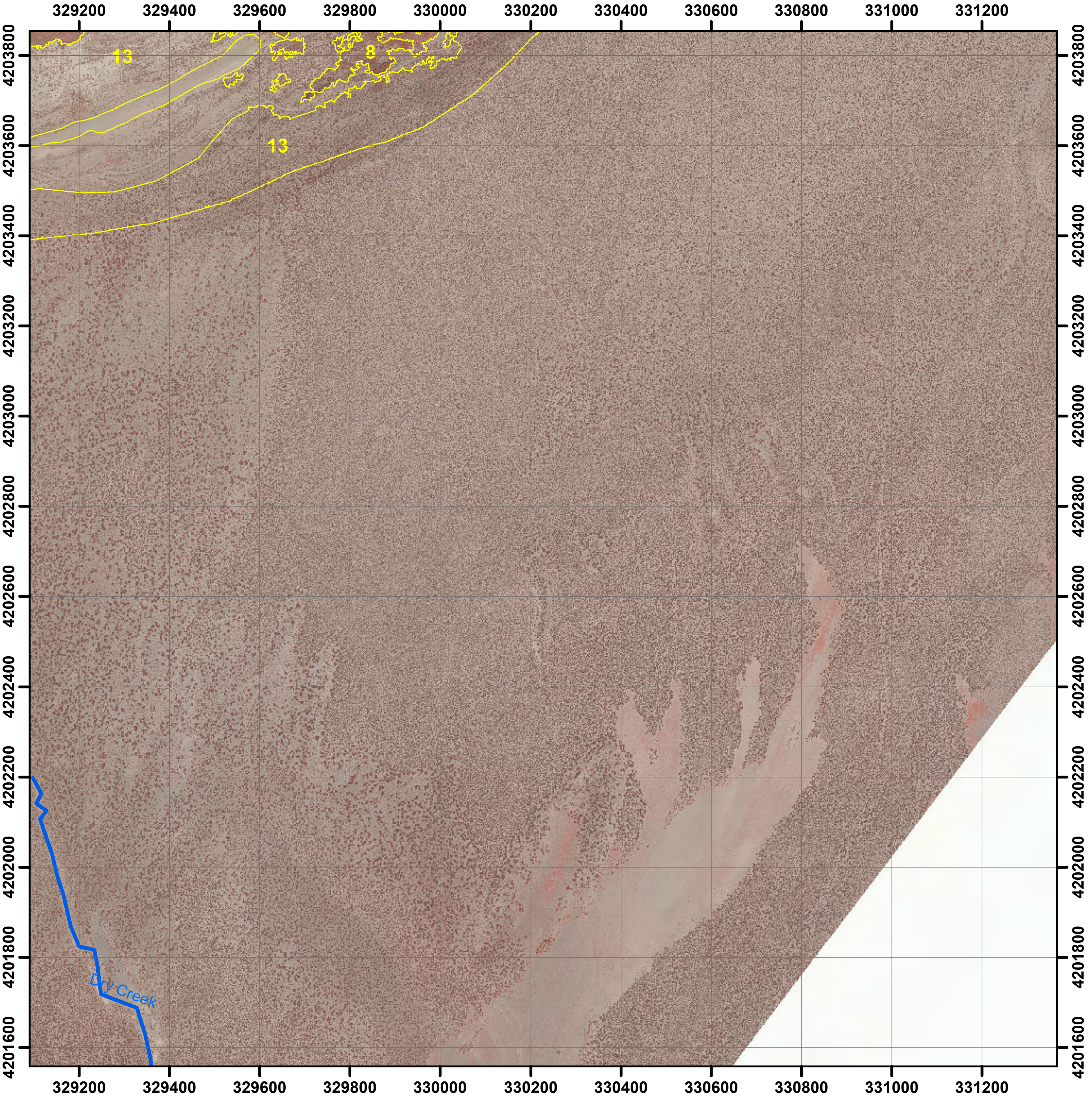
Mono Lake Landtype, 2014 Conditions

Map G10

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made
● Photopoint

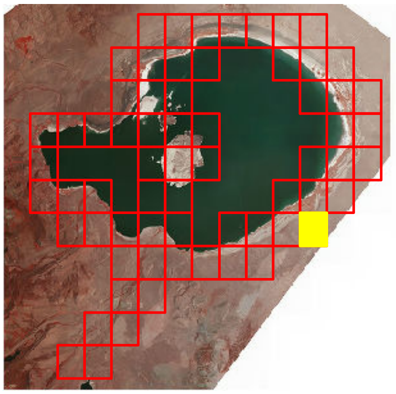


Note: Great Basin scrub is the combination of upland scrub, rabbitbrush, eolian, and pinyon woodland landtypes delineated in 2014; dry meadow/forb is rabbitbrush/meadow delineated in 2014; unvegetated is the combined area of barren lake bed and streambar delineated in 2014. Photopoints are linked to photographs in APPENDIX C.



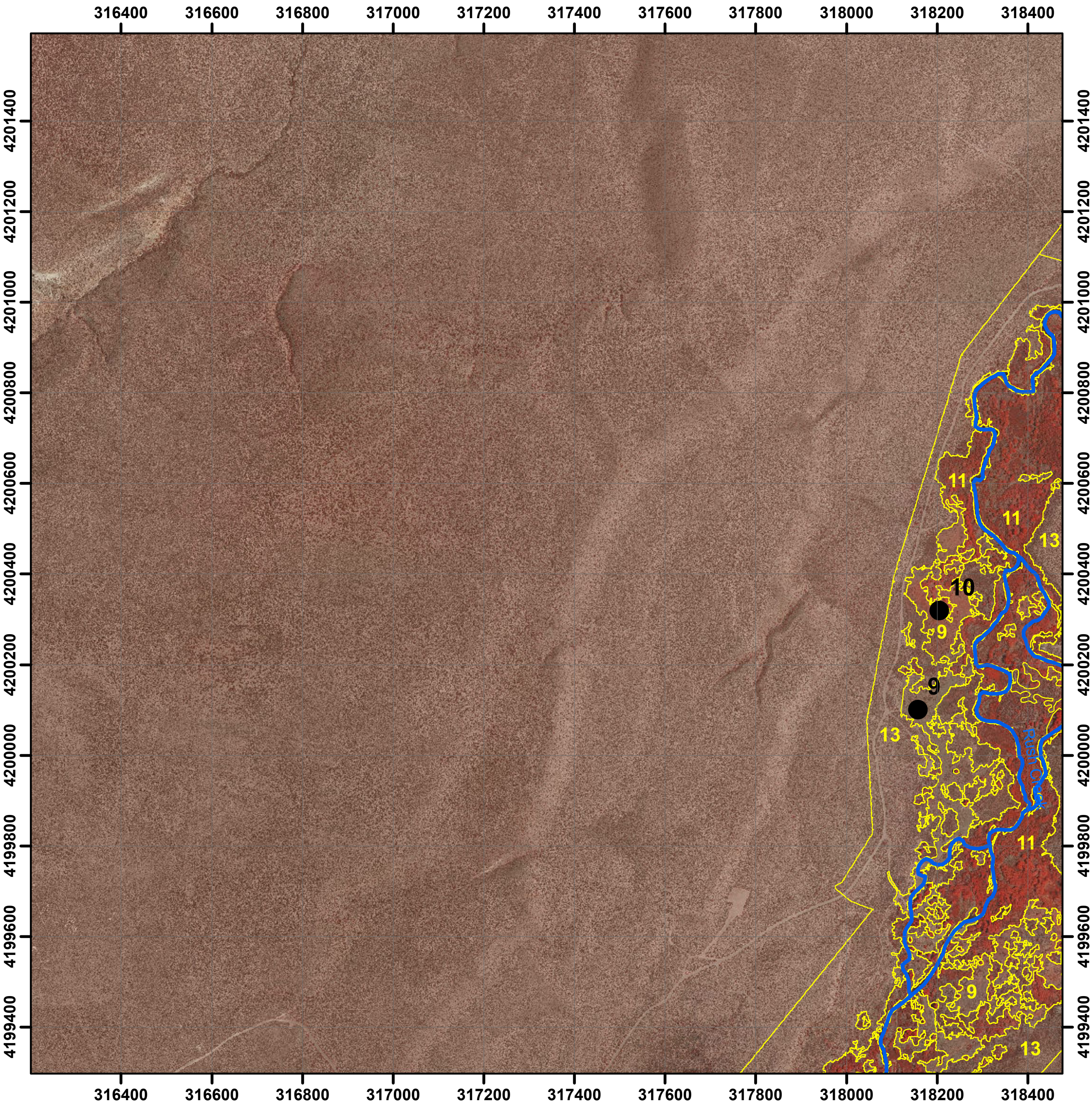
Mono Lake Landtype, 2014 Conditions

Map G11



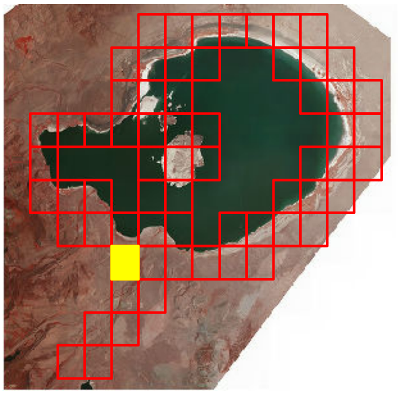
1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made
● Photopoint

Note: Great Basin scrub is the combination of upland scrub, rabbitbrush, eolian, and pinyon woodland landtypes delineated in 2014; dry meadow/forb is rabbitbrush/meadow delineated in 2014; unvegetated is the combined area of barren lake bed and streambar delineated in 2014. Photopoints are linked to photographs in APPENDIX C.



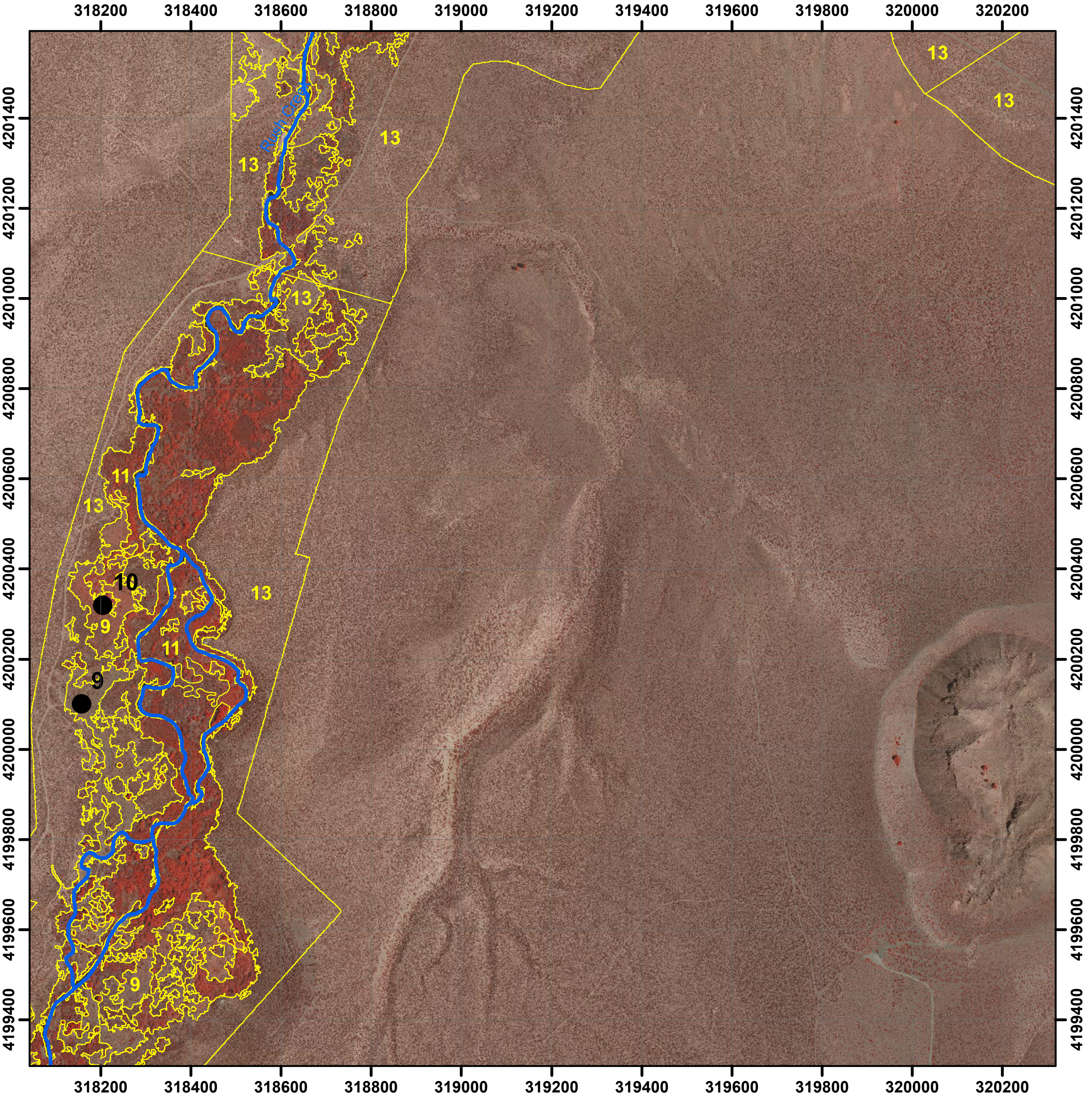
Mono Lake Landtype, 2014 Conditions

Map H4



1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made
● Photopoint

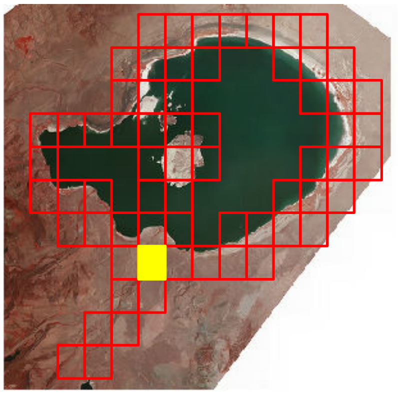
Note: Great Basin scrub is the combination of upland scrub, rabbitbrush, eolian, and pinyon woodland landtypes delineated in 2014; dry meadow/forb is rabbitbrush/meadow delineated in 2014; unvegetated is the combined area of barren lake bed and streambar delineated in 2014. Photopoints are linked to photographs in APPENDIX C.



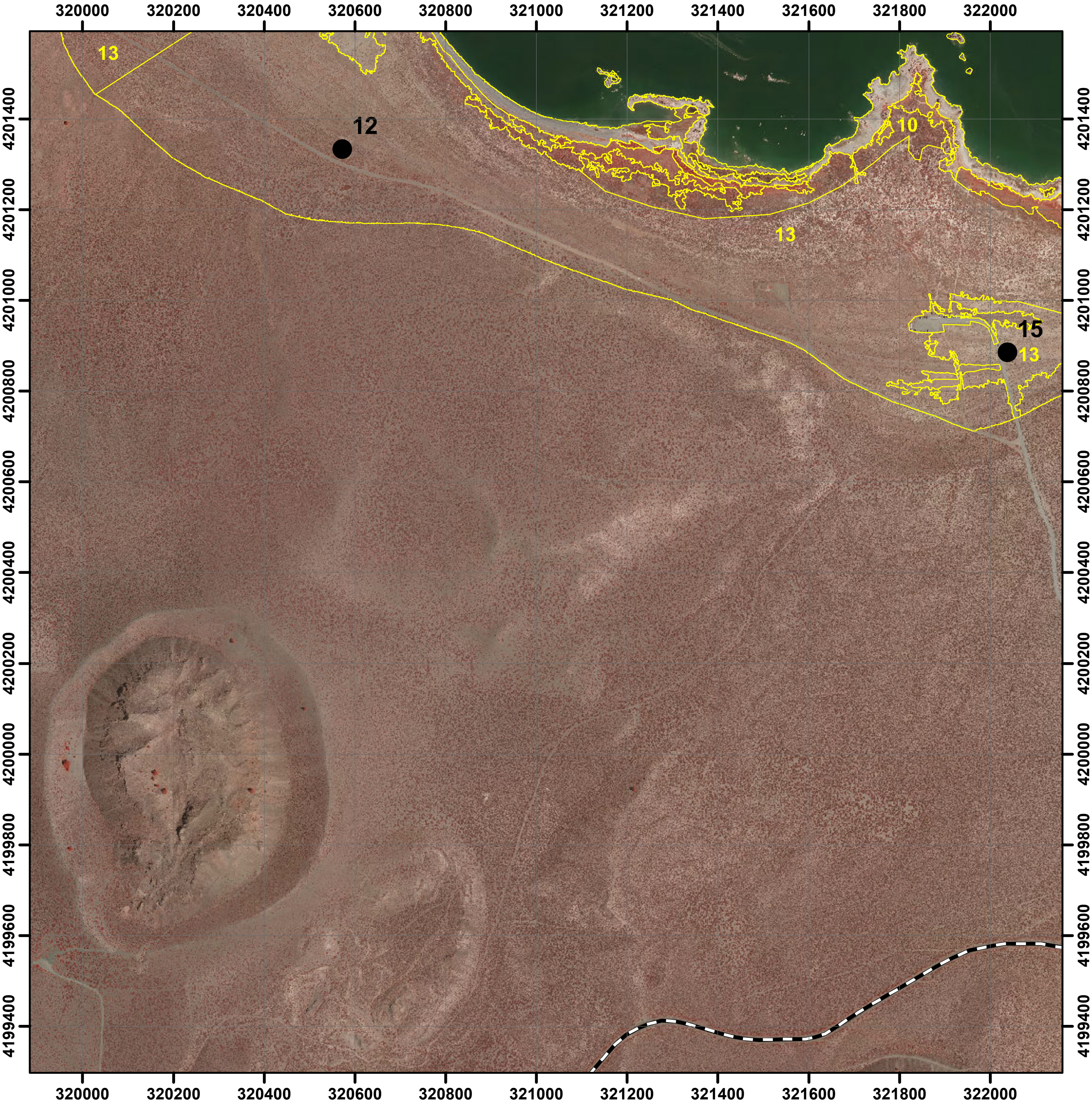
Mono Lake Landtype, 2014 Conditions

Map H5

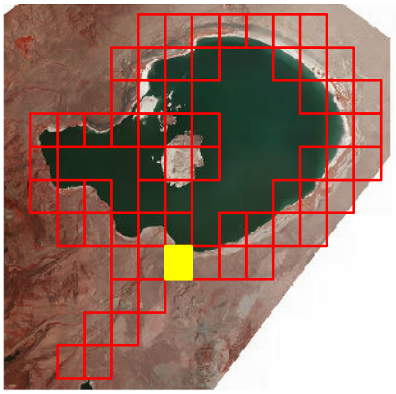
1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made
● Photopoint



Note: Great Basin scrub is the combination of upland scrub, rabbitbrush, eolian, and pinyon woodland landtypes delineated in 2014; dry meadow/forb is rabbitbrush/meadow delineated in 2014; unvegetated is the combined area of barren lake bed and streambar delineated in 2014. Photopoints are linked to photographs in APPENDIX C.

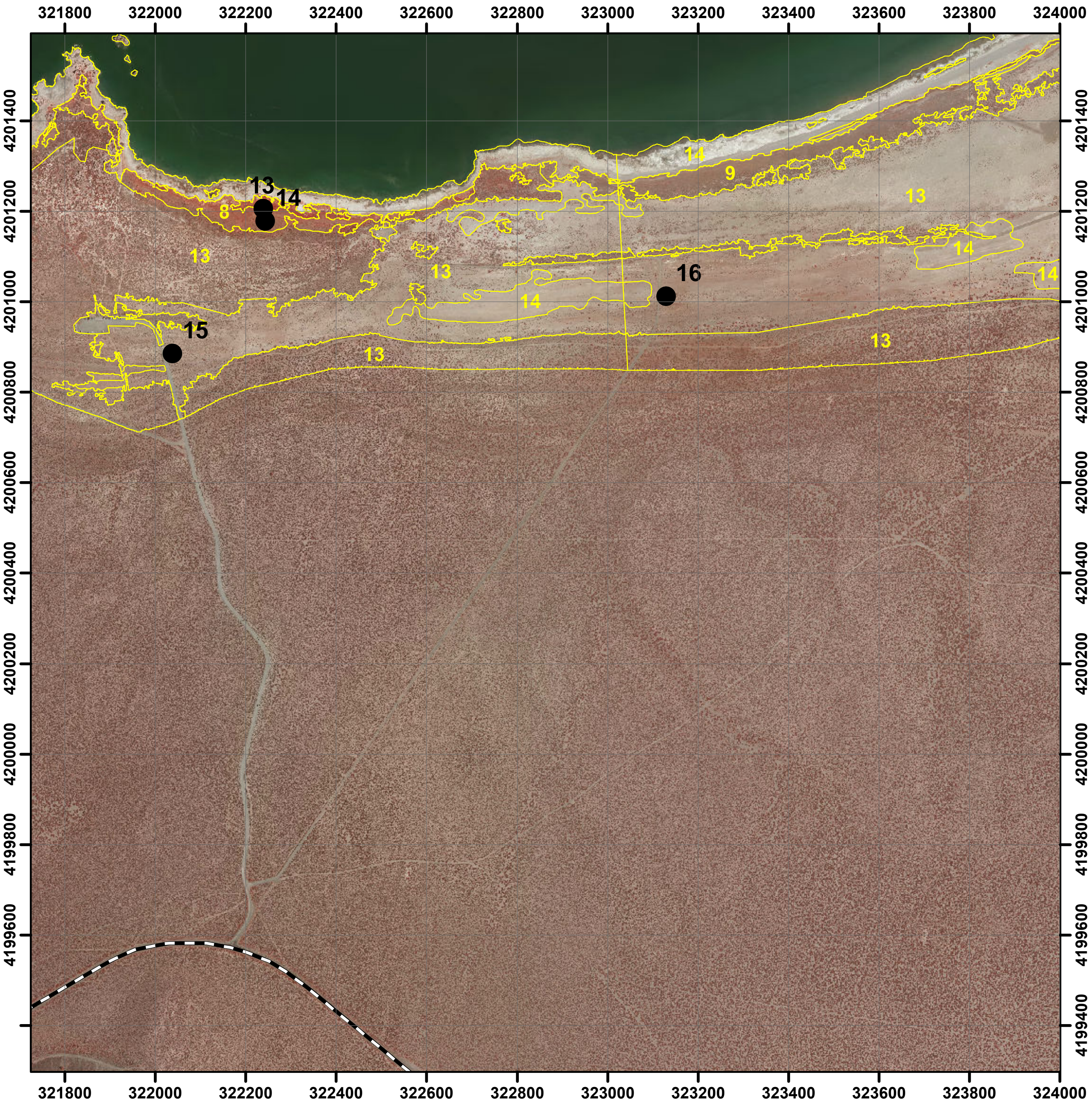


Mono Lake Landtype, 2014 Conditions
Map H6



1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made
● Photopoint

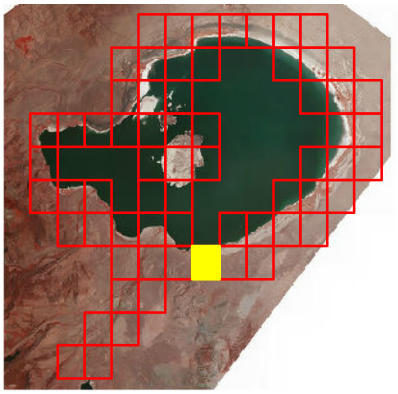
Note: Great Basin scrub is the combination of upland scrub, rabbitbrush, eolian, and pinyon woodland landtypes delineated in 2014; dry meadow/forb is rabbitbrush/meadow delineated in 2014; unvegetated is the combined area of barren lake bed and streambar delineated in 2014. Photopoints are linked to photographs in APPENDIX C.



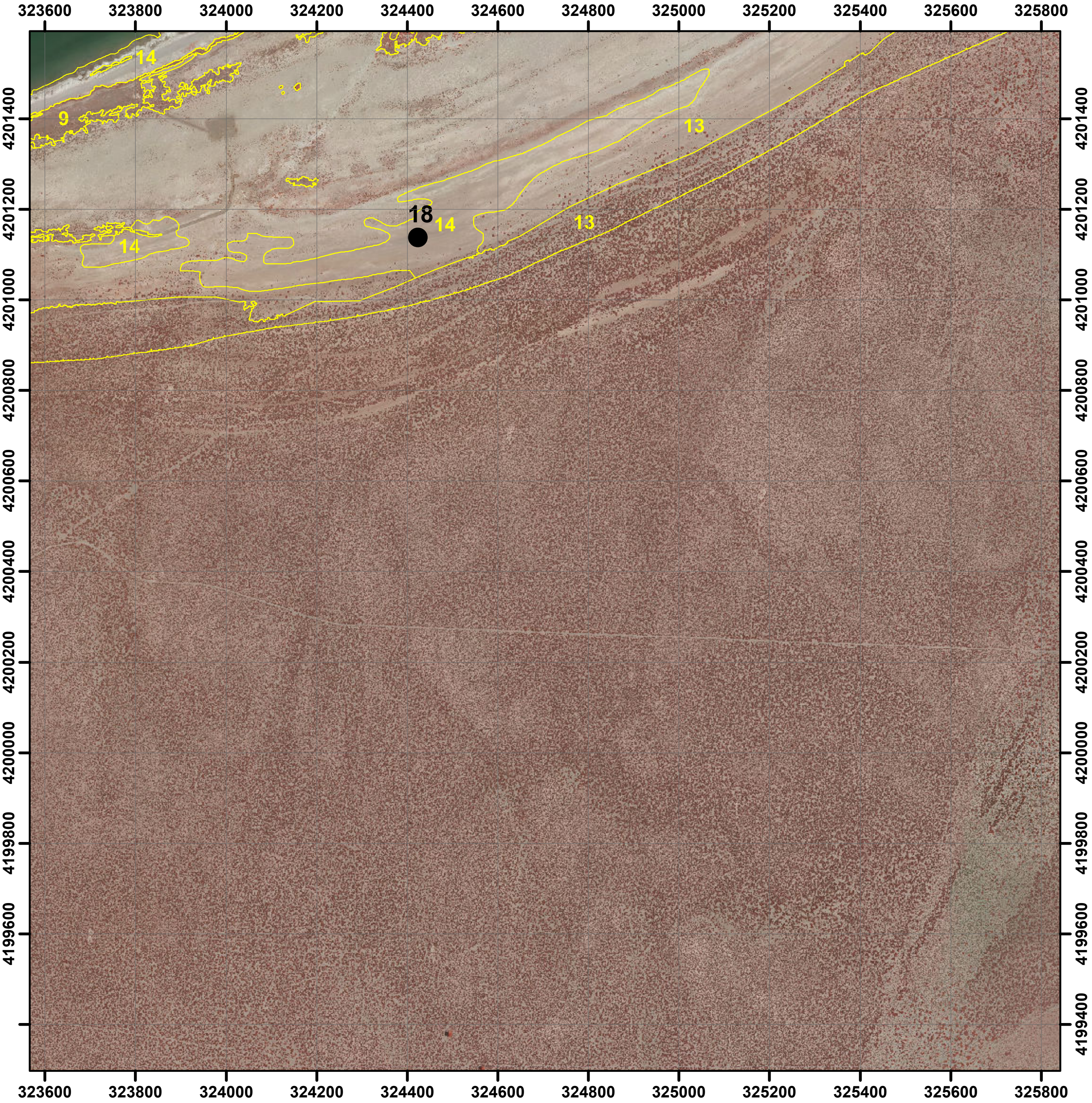
Mono Lake Landtype, 2014 Conditions

Map H7

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made
● Photopoint



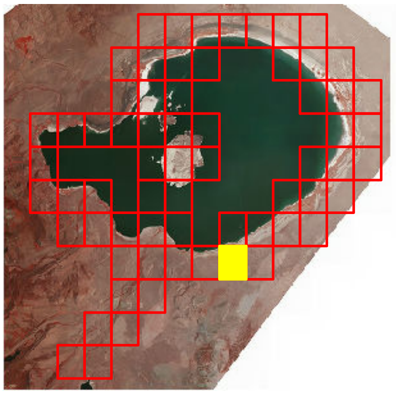
Note: Great Basin scrub is the combination of upland scrub, rabbitbrush, eolian, and pinyon woodland landtypes delineated in 2014; dry meadow/forb is rabbitbrush/meadow delineated in 2014; unvegetated is the combined area of barren lake bed and streambar delineated in 2014. Photopoints are linked to photographs in APPENDIX C.



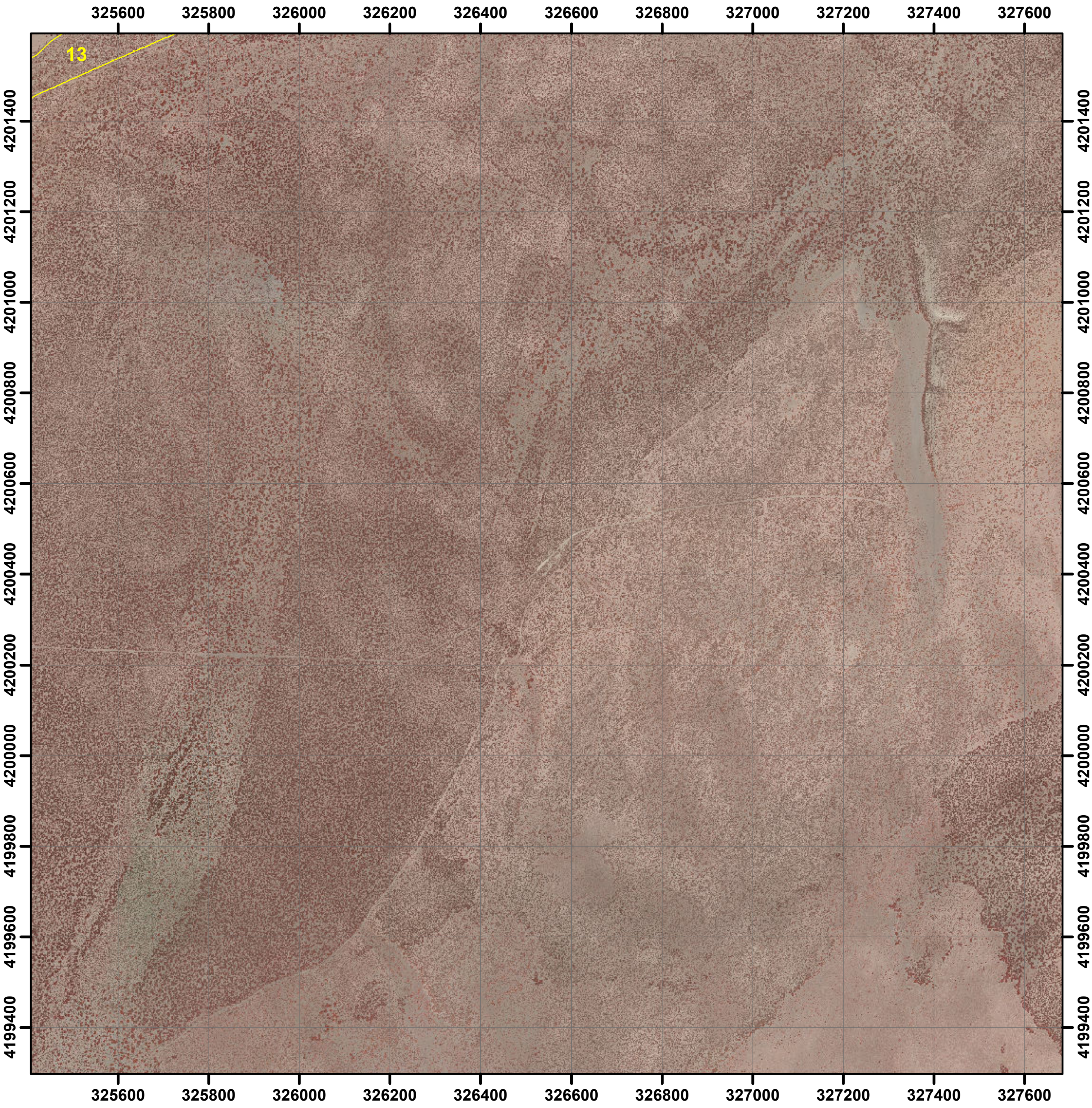
Mono Lake Landtype, 2014 Conditions

Map H8

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made
● Photopoint



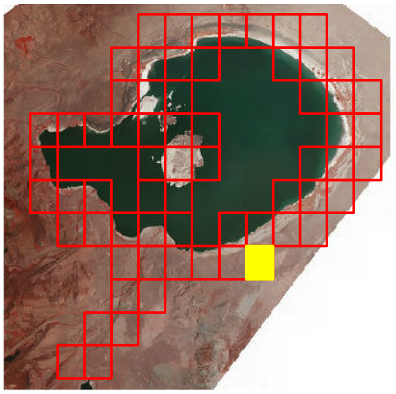
Note: Great Basin scrub is the combination of upland scrub, rabbitbrush, eolian, and pinyon woodland landtypes delineated in 2014; dry meadow/forb is rabbitbrush/meadow delineated in 2014; unvegetated is the combined area of barren lake bed and streambar delineated in 2014. Photopoints are linked to photographs in APPENDIX C.



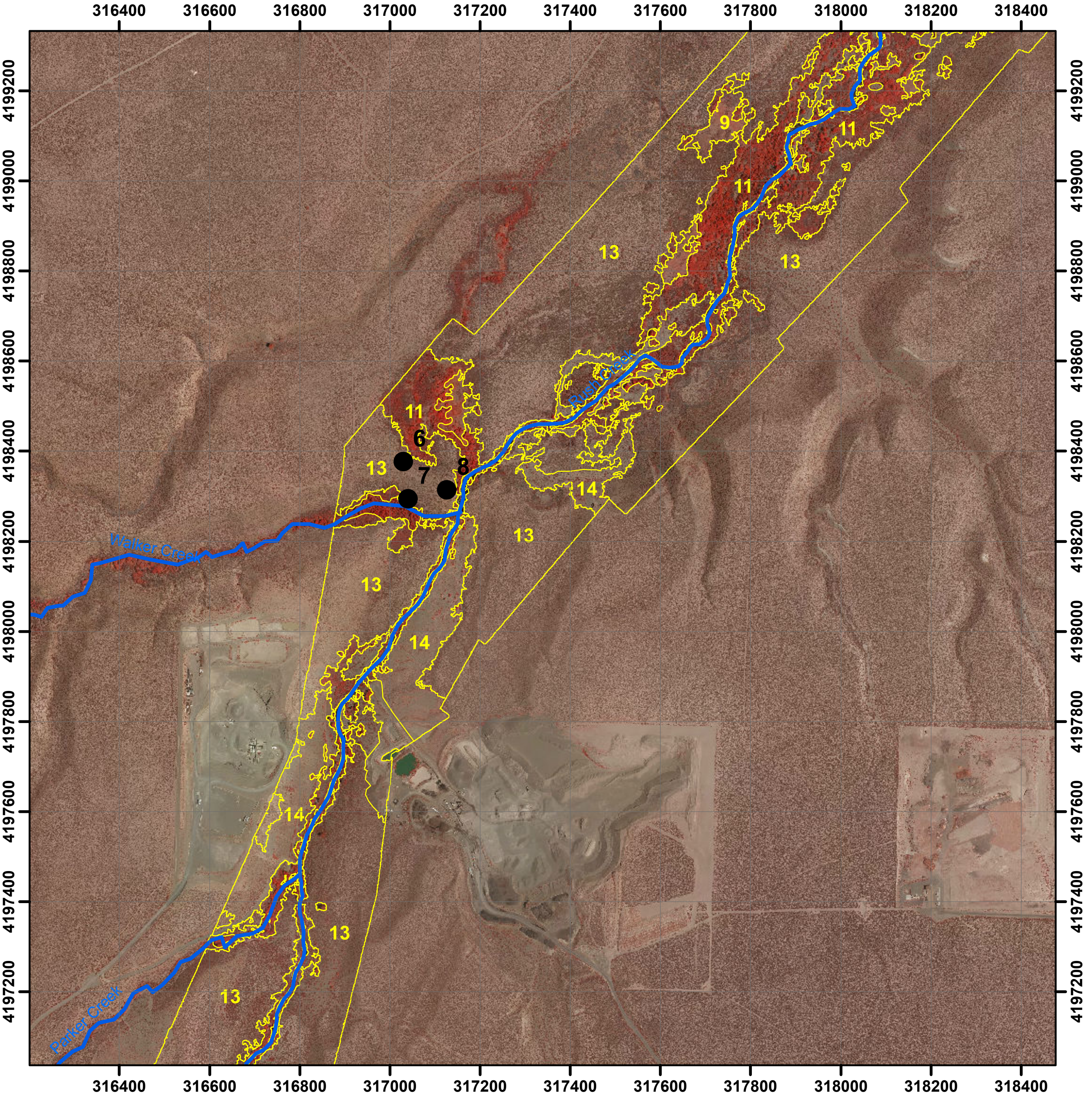
Mono Lake Landtype, 2014 Conditions

Map H9

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made
● Photopoint

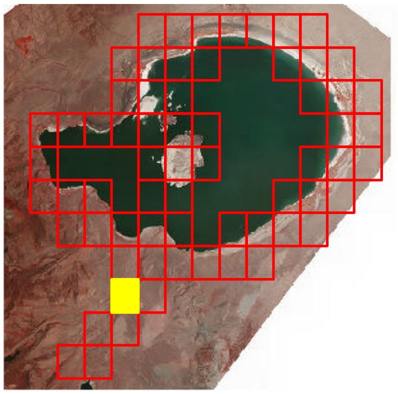


Note: Great Basin scrub is the combination of upland scrub, rabbitbrush, eolian, and pinyon woodland landtypes delineated in 2014; dry meadow/forb is rabbitbrush/meadow delineated in 2014; unvegetated is the combined area of barren lake bed and streambar delineated in 2014. Photopoints are linked to photographs in APPENDIX C.



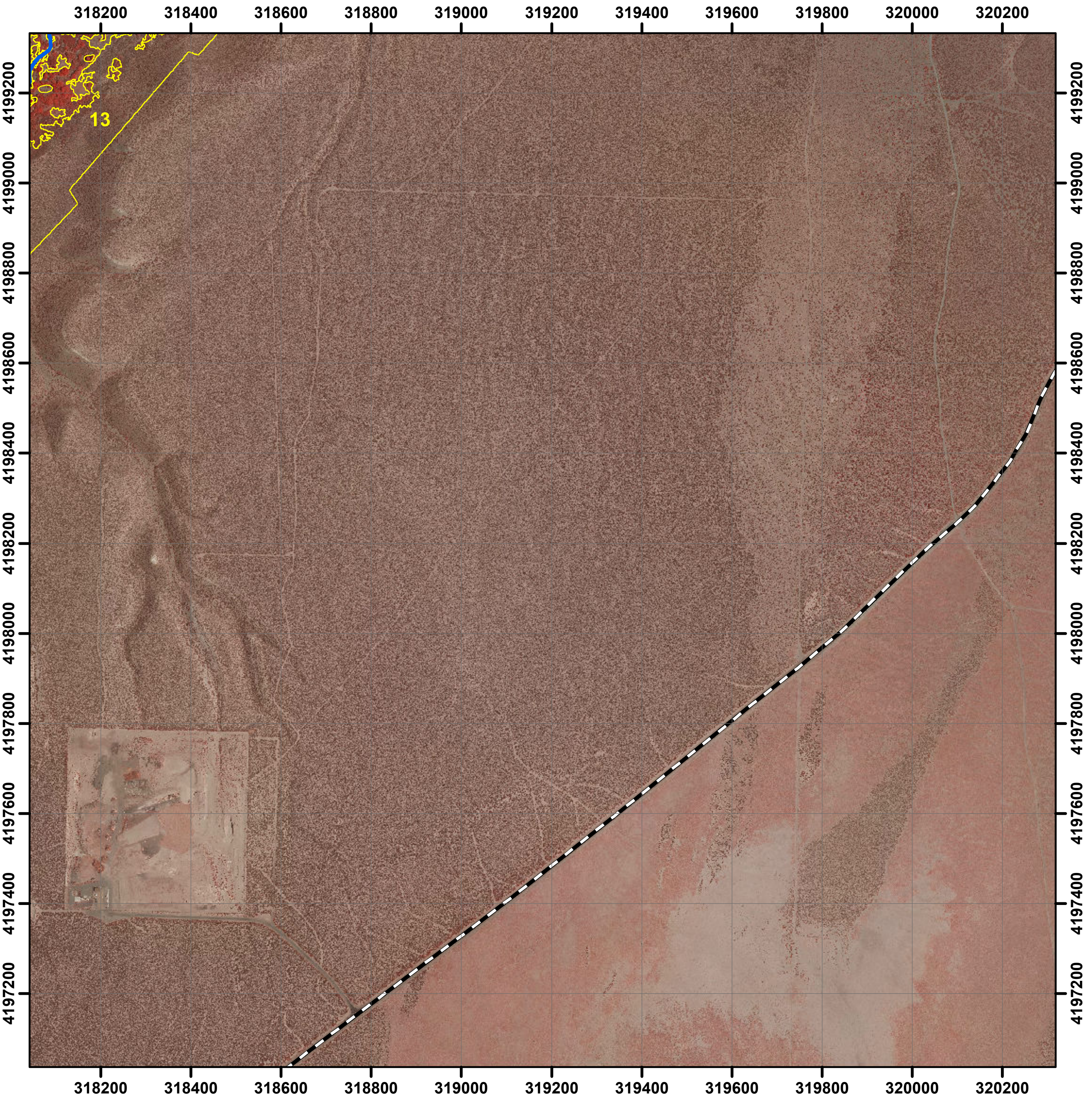
Mono Lake Landtype, 2014 Conditions

Map I4



1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made
● Photopoint

Note: Great Basin scrub is the combination of upland scrub, rabbitbrush, eolian, and pinyon woodland landtypes delineated in 2014; dry meadow/forb is rabbitbrush/meadow delineated in 2014; unvegetated is the combined area of barren lake bed and streambar delineated in 2014. Photopoints are linked to photographs in APPENDIX C.

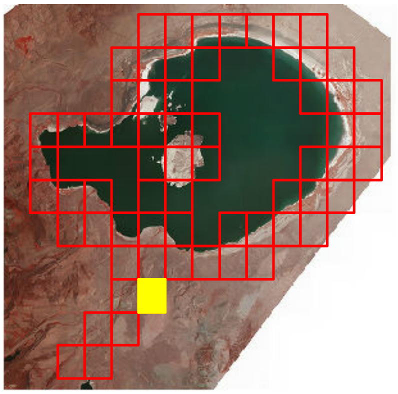


Mono Lake Landtype, 2014 Conditions

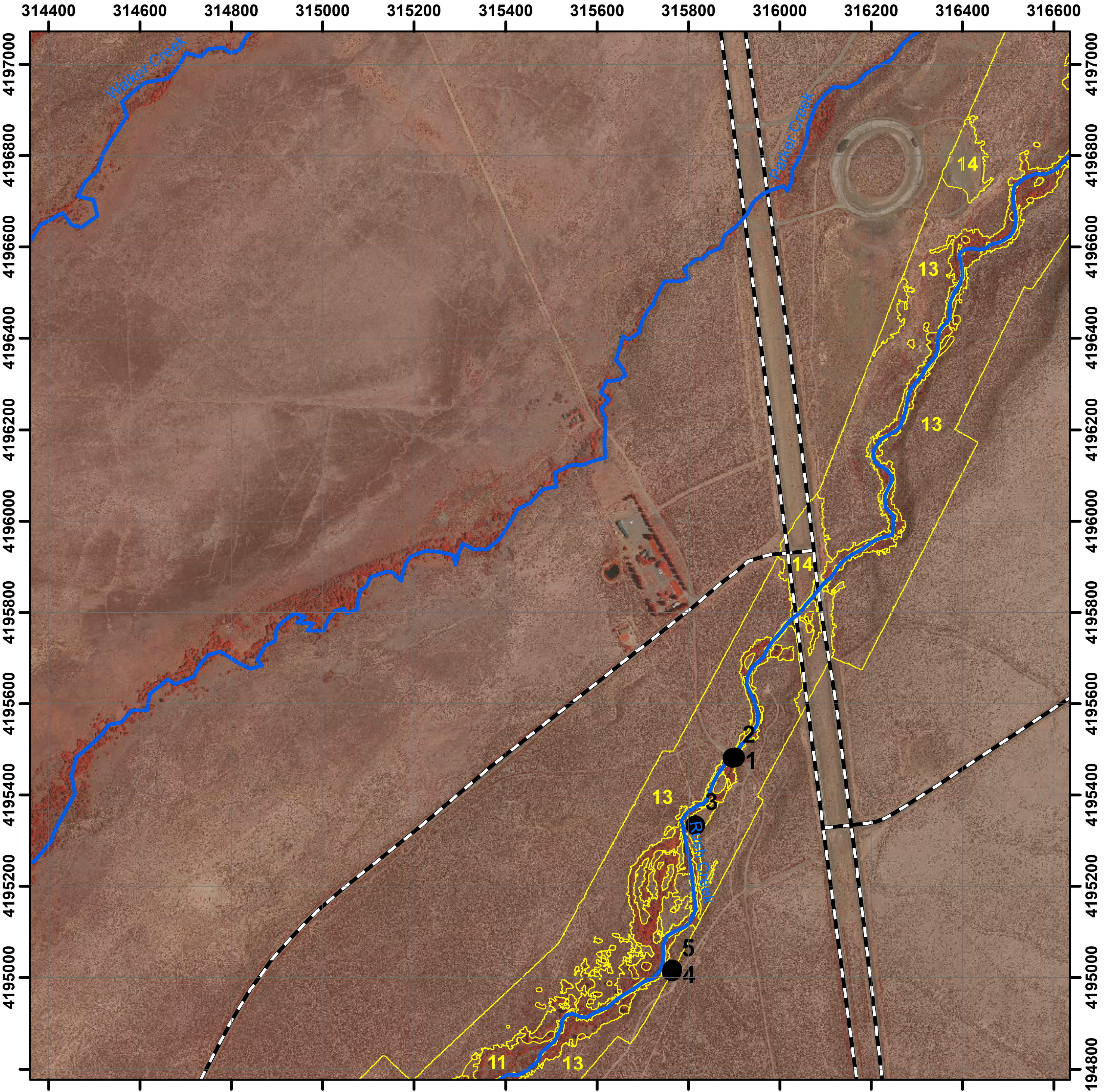
Map I5

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow

9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made
● Photopoint



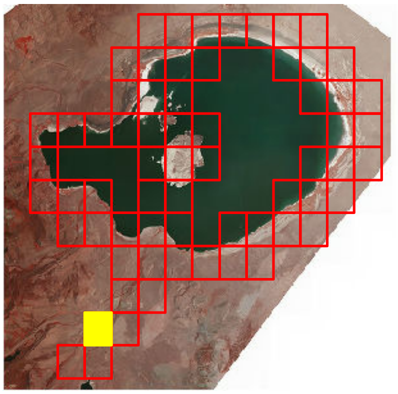
Note: Great Basin scrub is the combination of upland scrub, rabbitbrush, eolian, and pinyon woodland landtypes delineated in 2014; dry meadow/forb is rabbitbrush/meadow delineated in 2014; unvegetated is the combined area of barren lake bed and streambar delineated in 2014. Photopoints are linked to photographs in APPENDIX C.



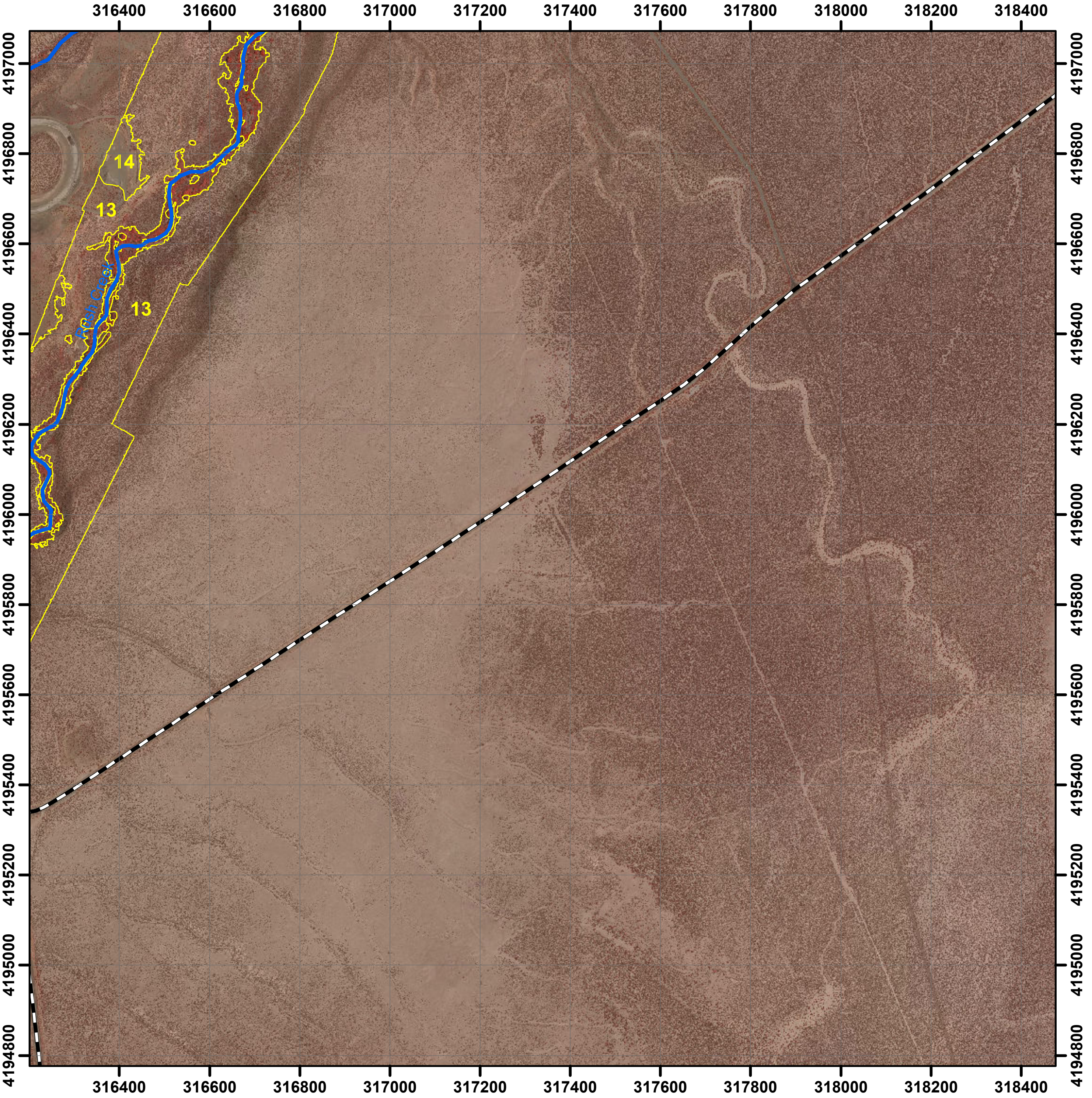
Mono Lake Landtype, 2014 Conditions

Map J3

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made
● Photopoint

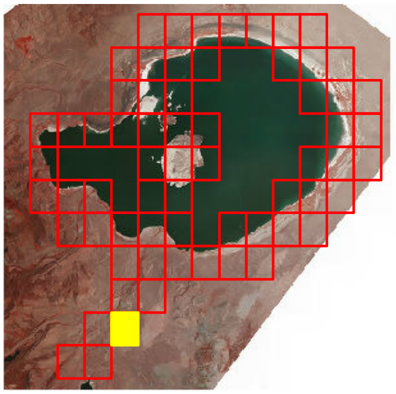


Note: Great Basin scrub is the combination of upland scrub, rabbitbrush, eolian, and pinyon woodland landtypes delineated in 2014; dry meadow/forb is rabbitbrush/meadow delineated in 2014; unvegetated is the combined area of barren lake bed and streambar delineated in 2014. Photopoints are linked to photographs in APPENDIX C.



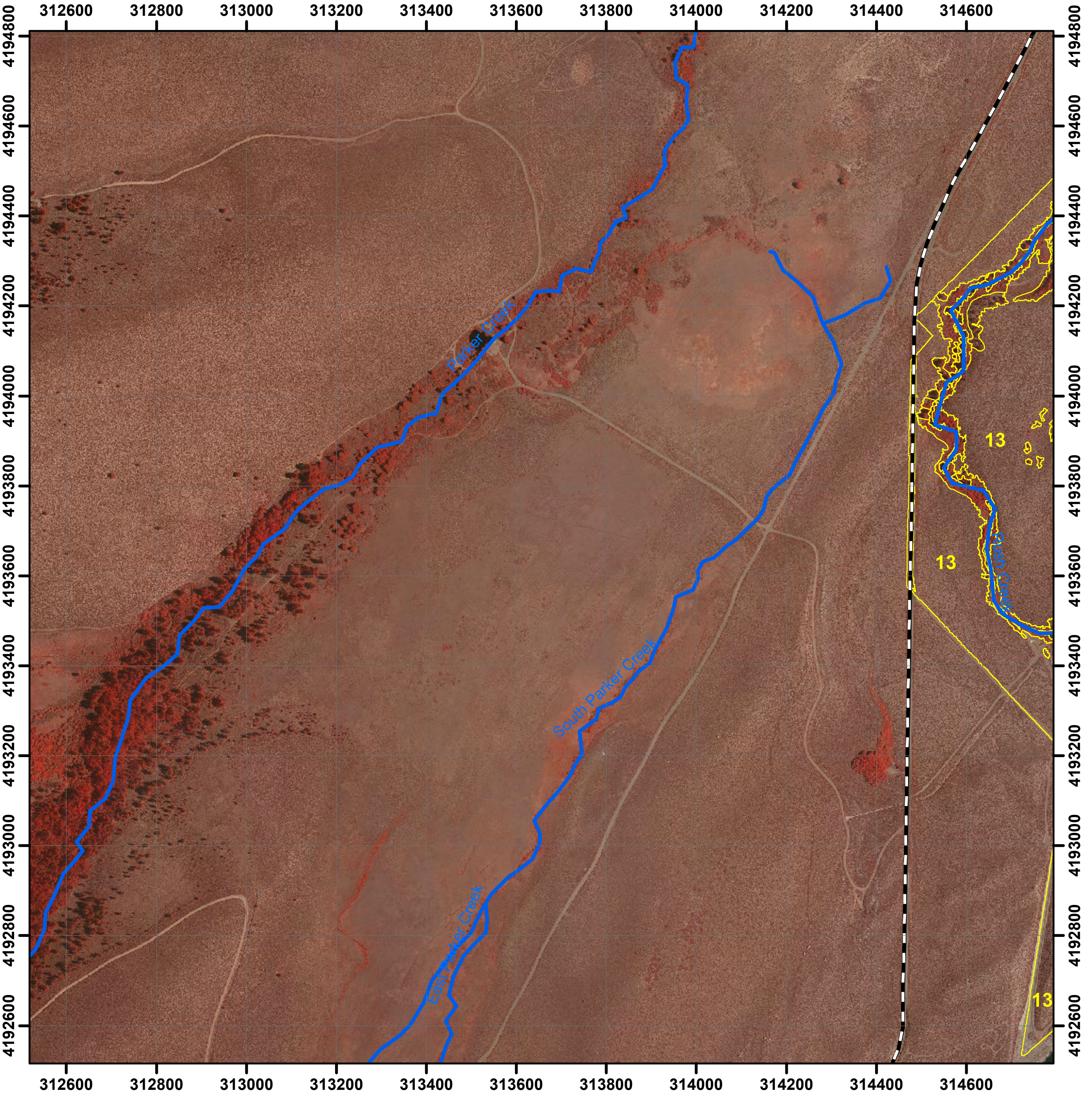
Mono Lake Landtype, 2014 Conditions

Map J4



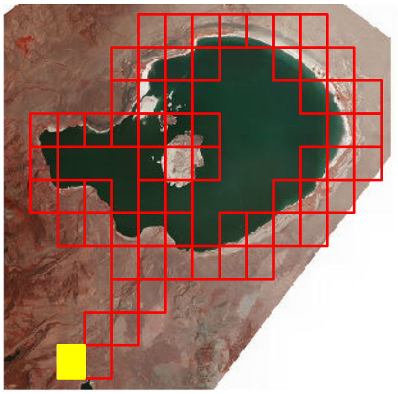
1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made
● Photopoint

Note: Great Basin scrub is the combination of upland scrub, rabbitbrush, eolian, and pinyon woodland landtypes delineated in 2014; dry meadow/forb is rabbitbrush/meadow delineated in 2014; unvegetated is the combined area of barren lake bed and streambar delineated in 2014. Photopoints are linked to photographs in APPENDIX C.

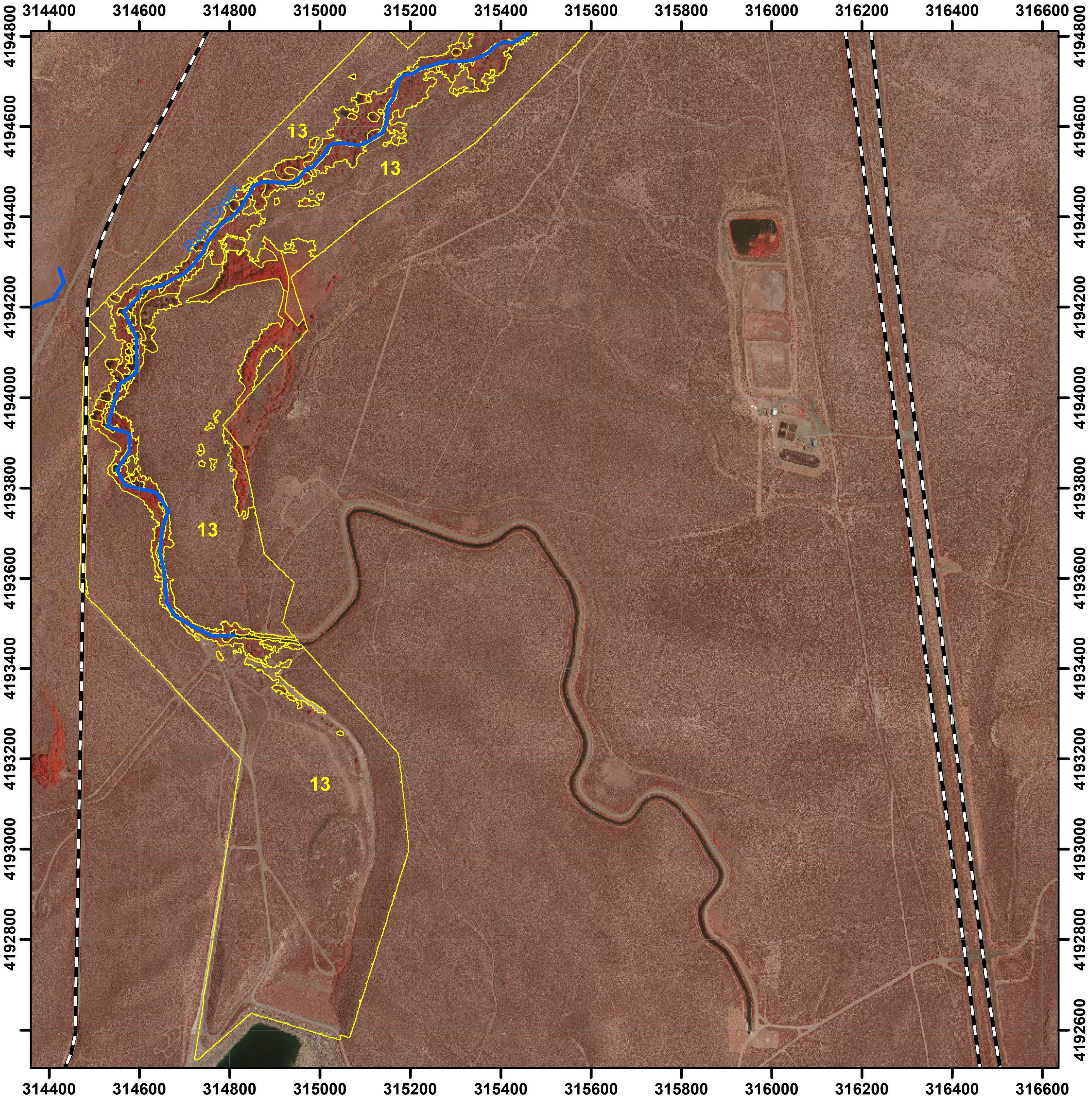


Mono Lake Landtype, 2014 Conditions
Map K2

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made
● Photopoint



Note: Great Basin scrub is the combination of upland scrub, rabbitbrush, eolian, and pinyon woodland landtypes delineated in 2014; dry meadow/forb is rabbitbrush/meadow delineated in 2014; unvegetated is the combined area of barren lake bed and streambar delineated in 2014. Photopoints are linked to photographs in APPENDIX C.

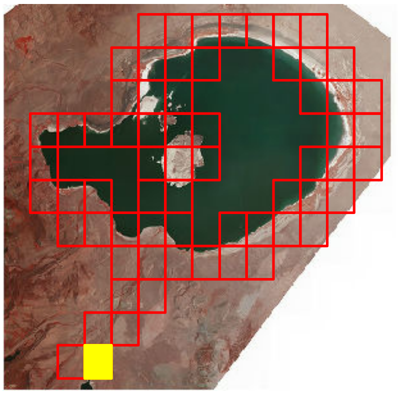


Mono Lake Landtype, 2014 Conditions

Map K3

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow

9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made
● Photopoint



Note: Great Basin scrub is the combination of upland scrub, rabbitbrush, eolian, and pinyon woodland landtypes delineated in 2014; dry meadow/forb is rabbitbrush/meadow delineated in 2014; unvegetated is the combined area of barren lake bed and streambar delineated in 2014. Photopoints are linked to photographs in APPENDIX C.

APPENDIX C
PHOTOGRAPHS

Photopoint 1. Rush Creek subarea; looking downstream; riparian shrub borders channel.

Photopoint 2. Rush Creek subarea; looking upsream; riparian shrub borders channel.

Photopoint 3. Rush Creek subarea; unvegetated streambar.

Photopoint 4. Rush Creek subarea overview; looking downstream.

Photopoint 5. Rush Creek subarea; looking upstream; riparian shrub borders channel.

Photopoint 6. Rush Creek subarea; riparian scrub and alkali meadow.

Photopoint 7. Walker Creek; riparian woodland (aspen) and riparian shrub.

Photopoint 8. Rush Creek overview; looking downstream; riparian shrub borders channel.

Photopoint 9. Rush Creek; unvegetated streambar.

Photopoint 10. Rush Creek; alkali wet meadow.

Photopoint 11. Rush Creek delta subarea; Great Basin scrub.

Photopoint 12. South tufa subarea; Great Basin scrub.

Photopoint 13. South tufa subarea; freshwater pond surrounded by marsh.

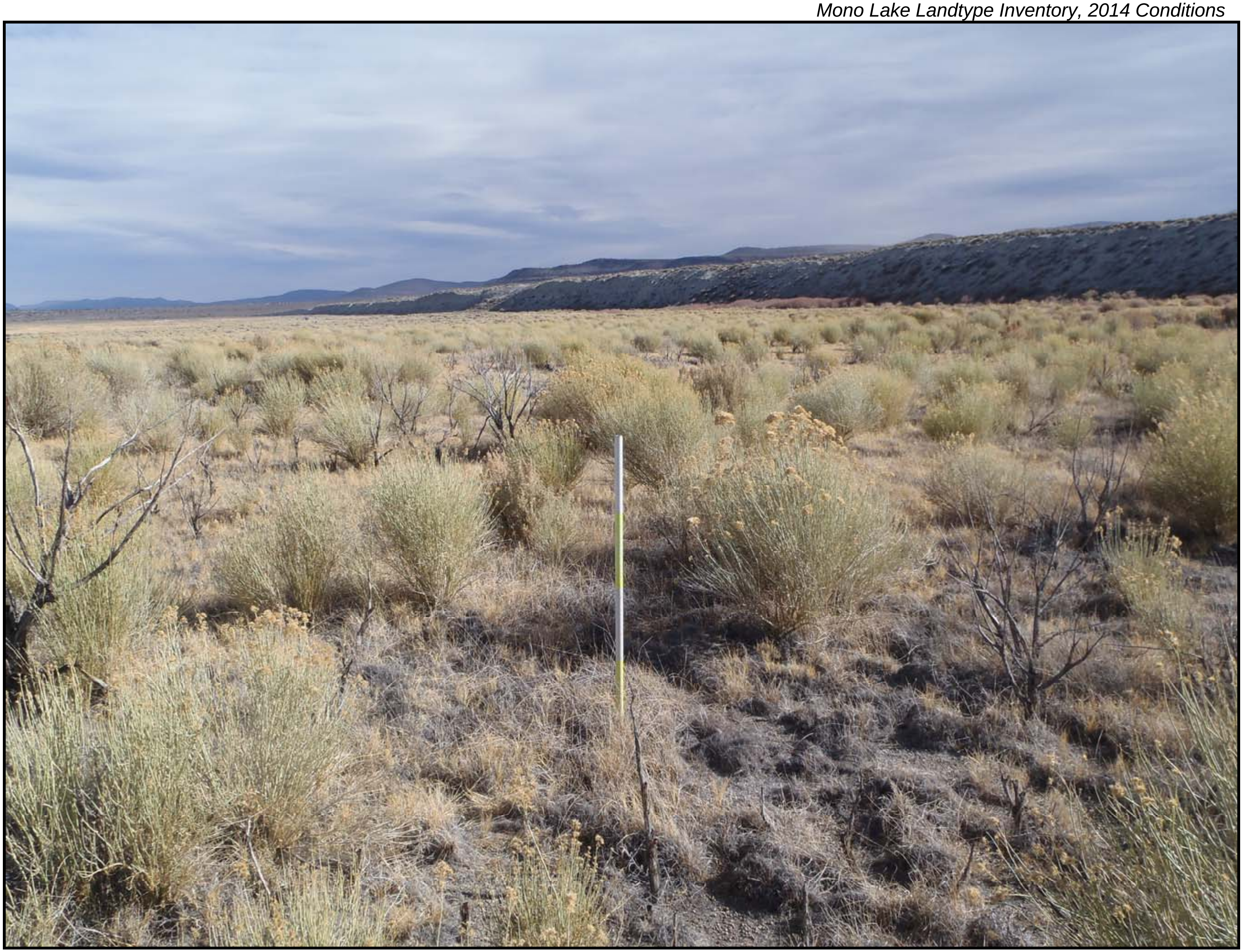
Photopoint 14. South tufa subarea; wet meadow.

Photopoint 15. South tufa subarea; rabbitbrush scrub.

Photopoint 16. South shore lagoon subarea; rabbitbrush scrub.

Photopoint 17. South shore lagoon subarea; alkali wet meadow.

Photopoint 18. South shore lagoon subarea; unvegetated lake bed.

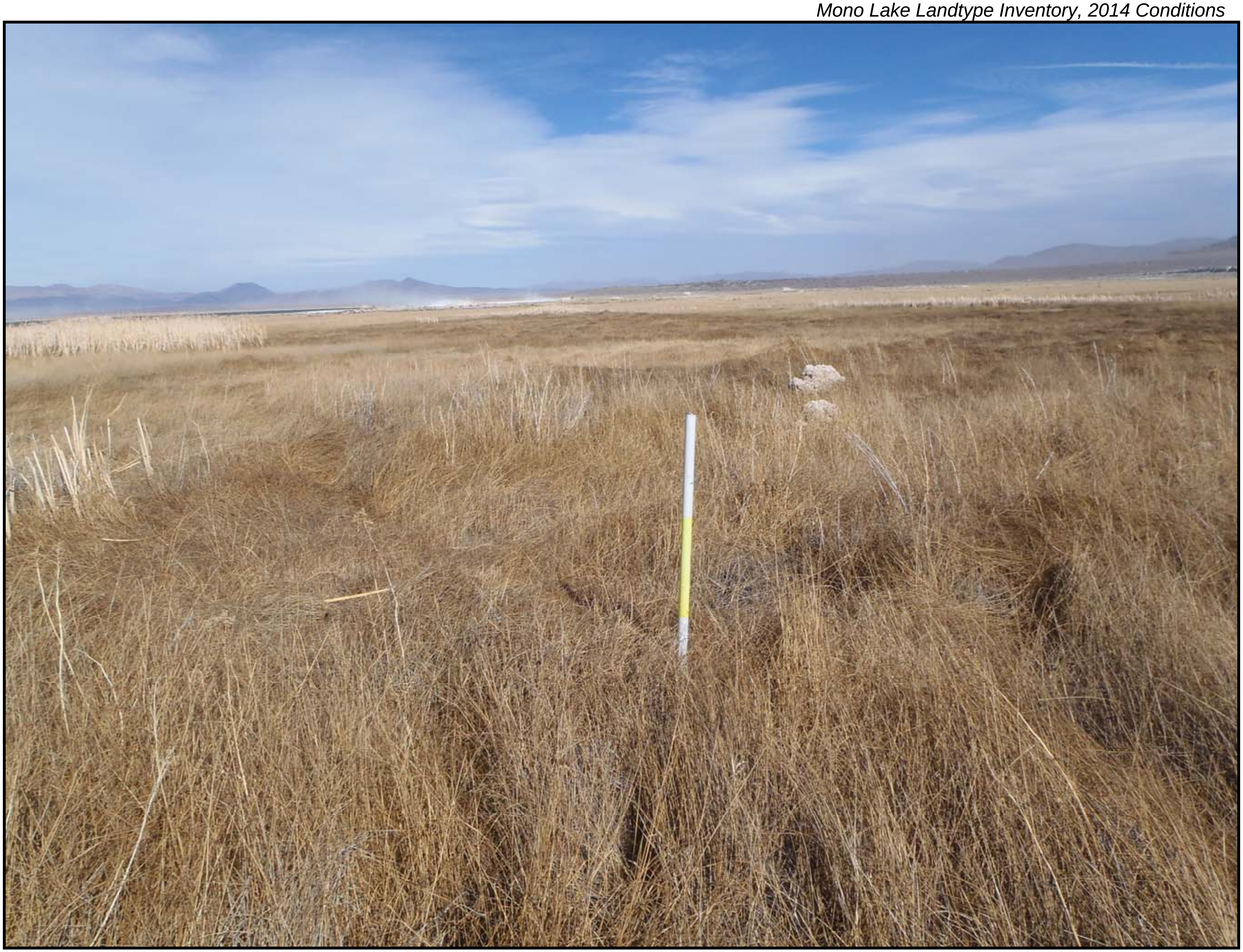


Photopoint 19. Sammonn Spring subarea; rabbitbrush/meadow.

Photopoint 20. Sammonn Spring subarea; wet meadow and marsh.

Photopoint 21. Sammonn Spring subarea; rabbitbrush scrub and unvegetated.

Photopoint 22. Sammonn Spring subarea; freshwater pond and marsh.

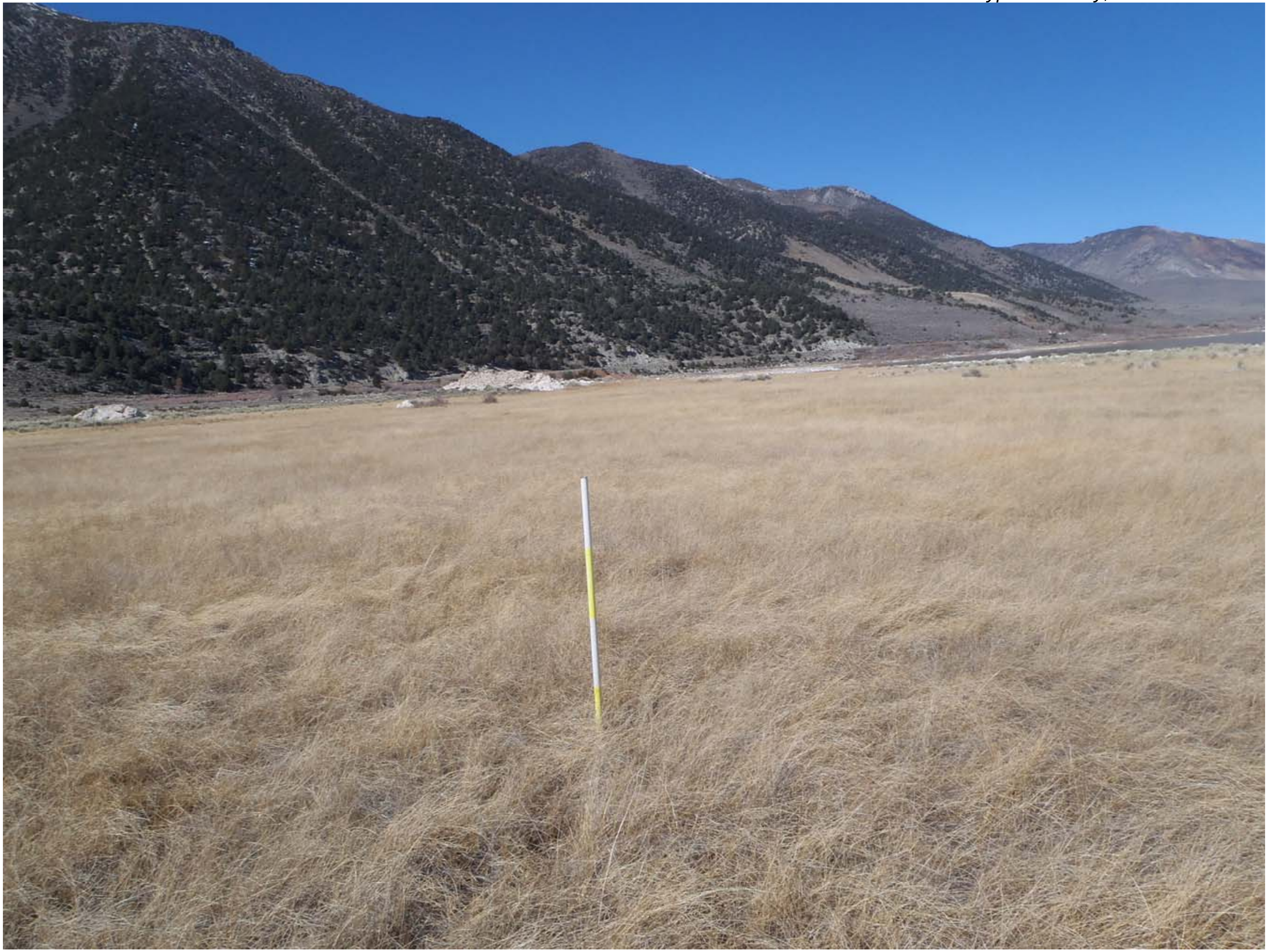


Photopoint 23. Sammonn Spring subarea; wet meadow.

Photopoint 25. West shore/Lee Vining delta subarea; rabbitbrush scrub.

Photopoint 26. West shore/Lee Vining delta subarea; unvegetated barren lake bed.

Photopoint 27. West shore/Lee Vining delta subarea; rabbitbrush/meadow and riparian shrub.



Photopoint 28. West shore/Lee Vining delta subarea; wet meadow.

Photopoint 29. West shore/Lee Vining delta subarea; marsh.

Photopoint 30. West shore/Lee Vining delta subarea overview.

Photopoint 31. Dechambeau Creek delta subarea; marsh and wet meadow.

Photopoint 32. Dechambeau Embayment subarea; rabbitbrush scrub.

Photopoint 33. Dechambeau Embayment subarea overview; south.

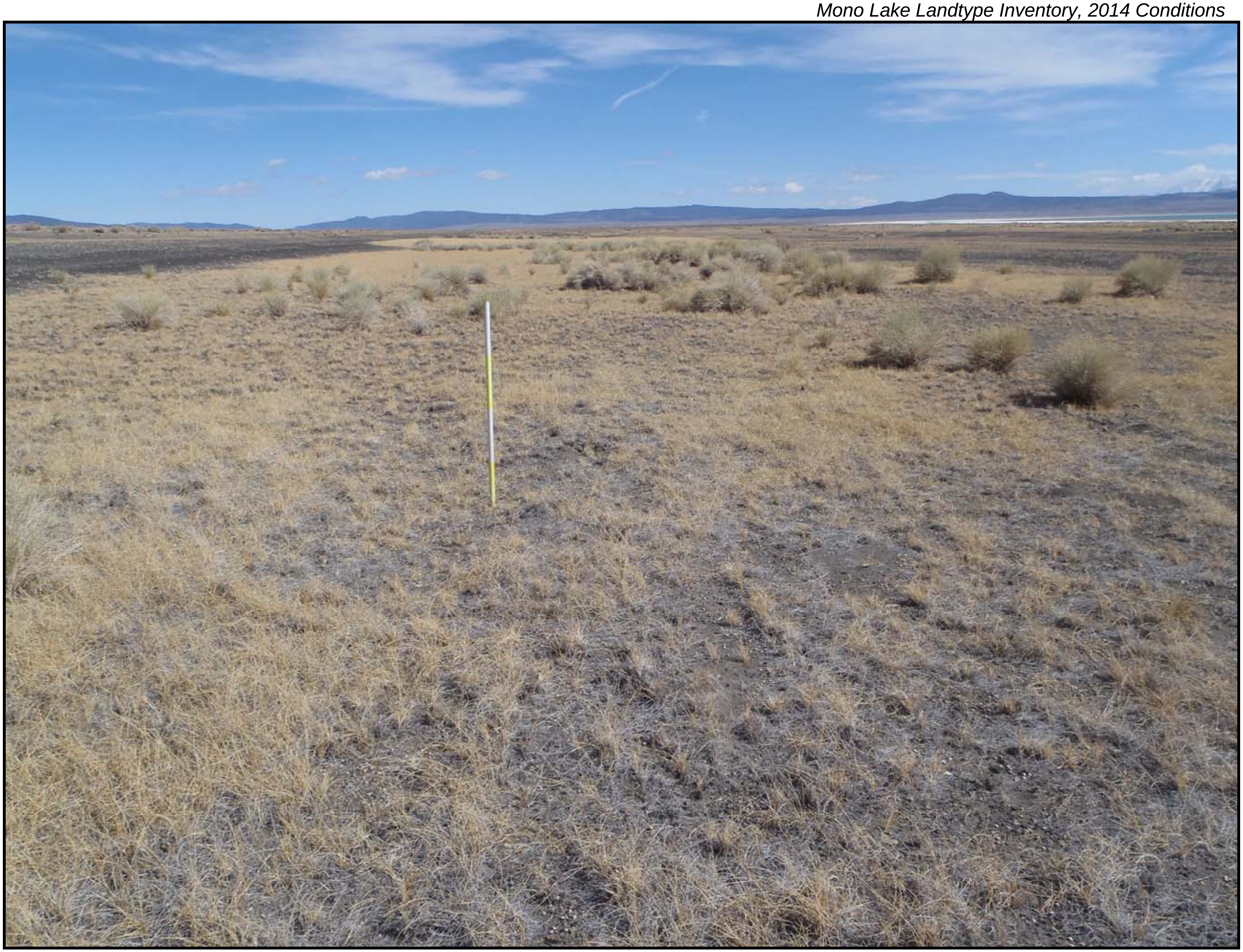
Photopoint 34. Dechambeau Embayment subarea overview; east.

Photopoint 35. Dechambeau Embayment subarea overview; northeast.

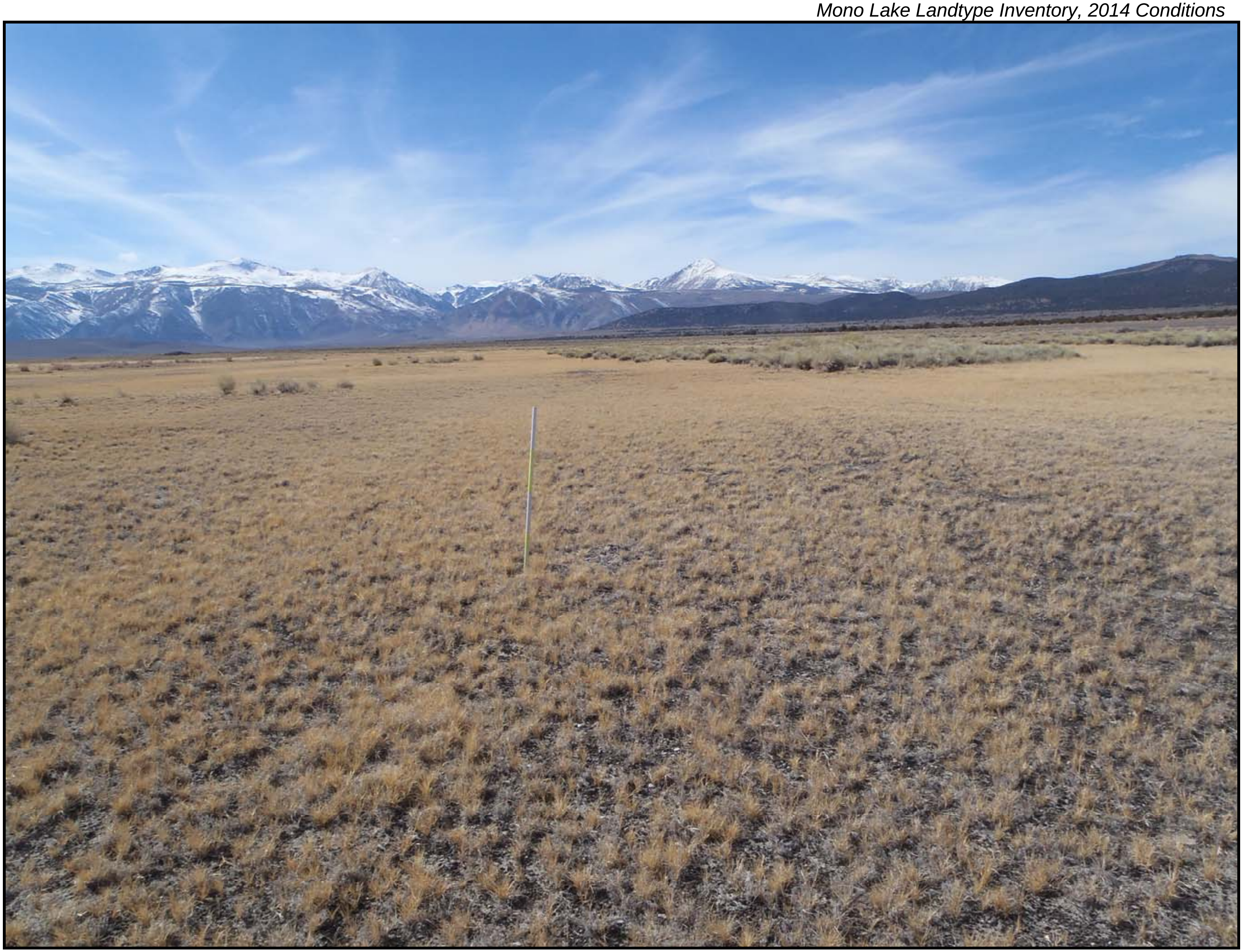
Photopoint 36. Mill/Wilson Creek delta subareas; unvegetated barren lake bed.

Photopoint 37. Mill/Wilson Creek delta subareas; unvegetated barren lake bed.

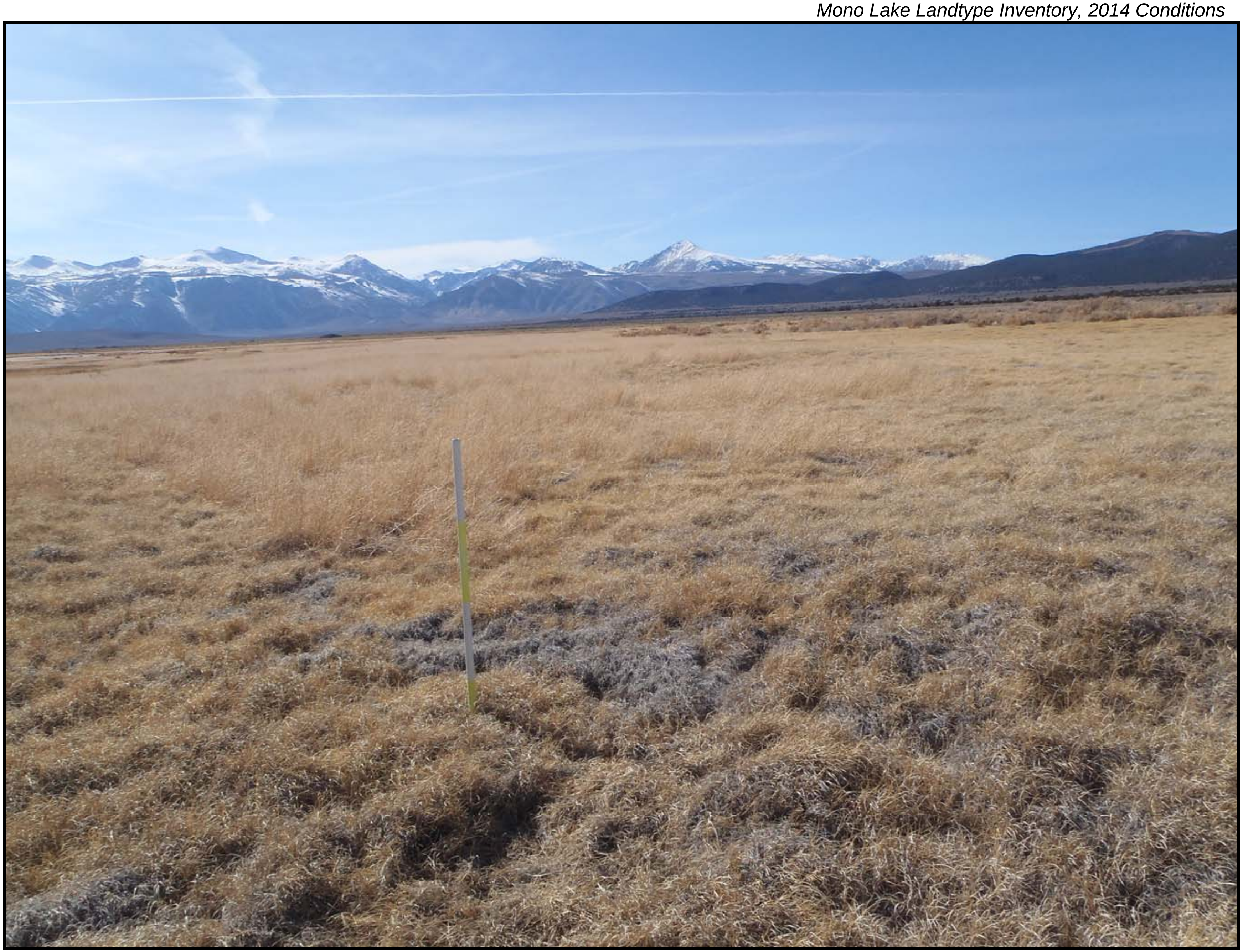
Photopoint 38. Bridgeport Creek delta subarea; unvegetated barren lake bed.



Photopoint 39. Bridgeport Creek delta subarea; alkali wet meadow and dry meadow/forb.



Photopoint 40. Bridgeport Creek delta subarea; alakali wet meadow.



Photopoint 41. Bridgeport Creek delta subarea; wet meadow.

APPENDIX D

MONO LAKE LANDTYPE MAPS
1999, 2005, 2009, and 2014 CONDITIONS

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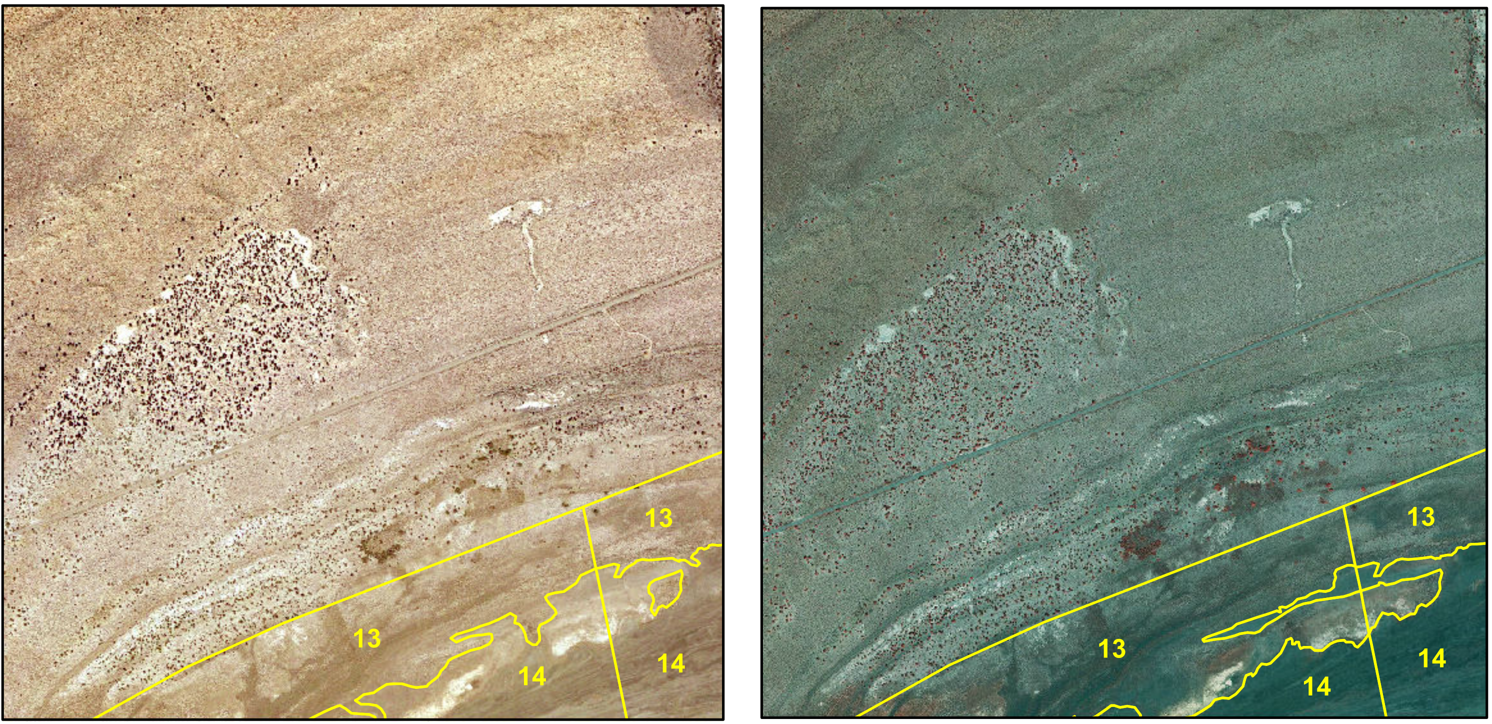
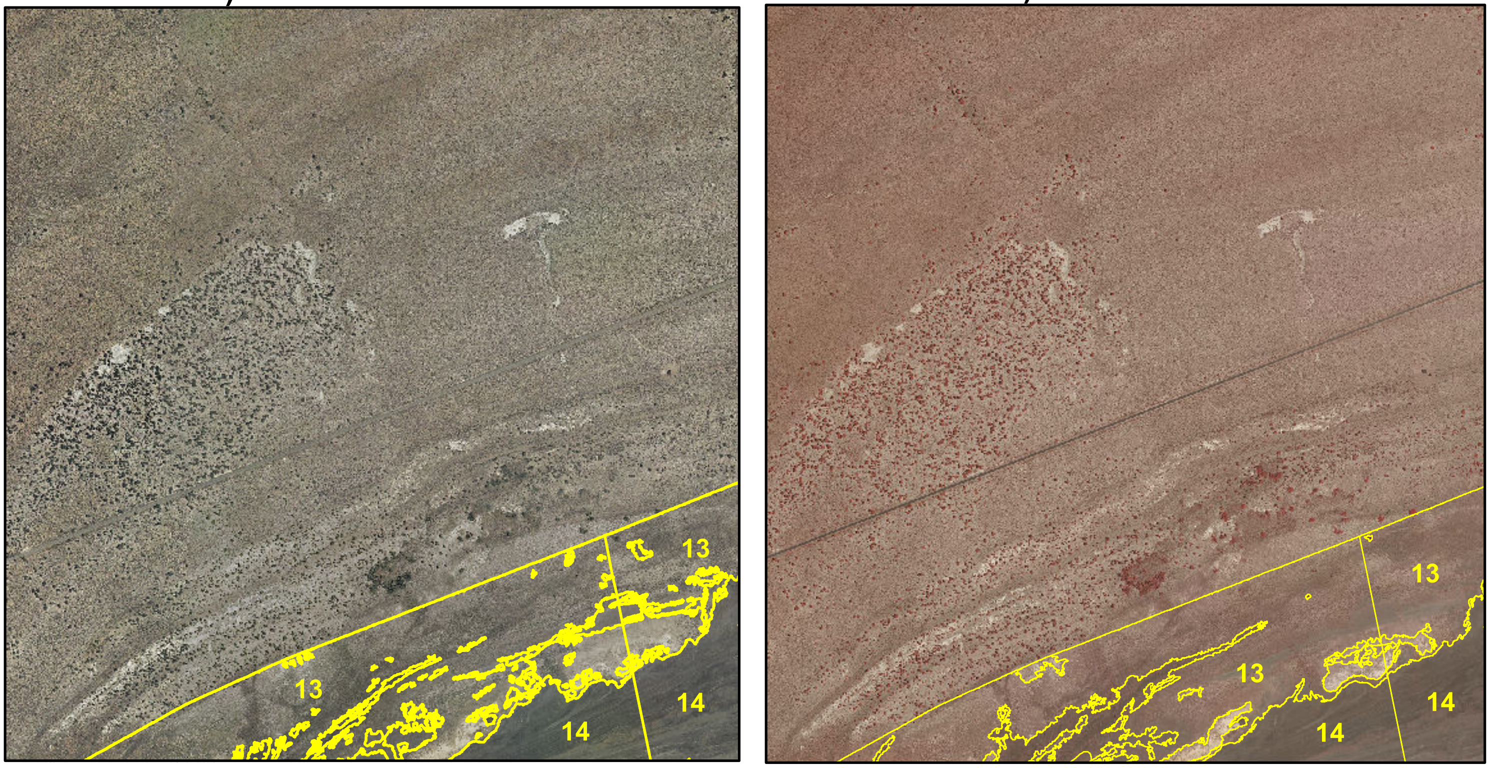


A) 1999 conditions.

B) 2005 conditions.



C) 2009 conditions.

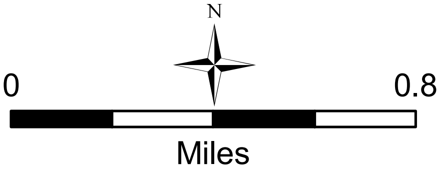
D) 2014 conditions.

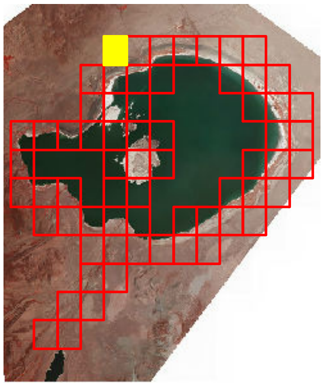
Mono Lake Landtype, Historical Conditions

Landtype Legend

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

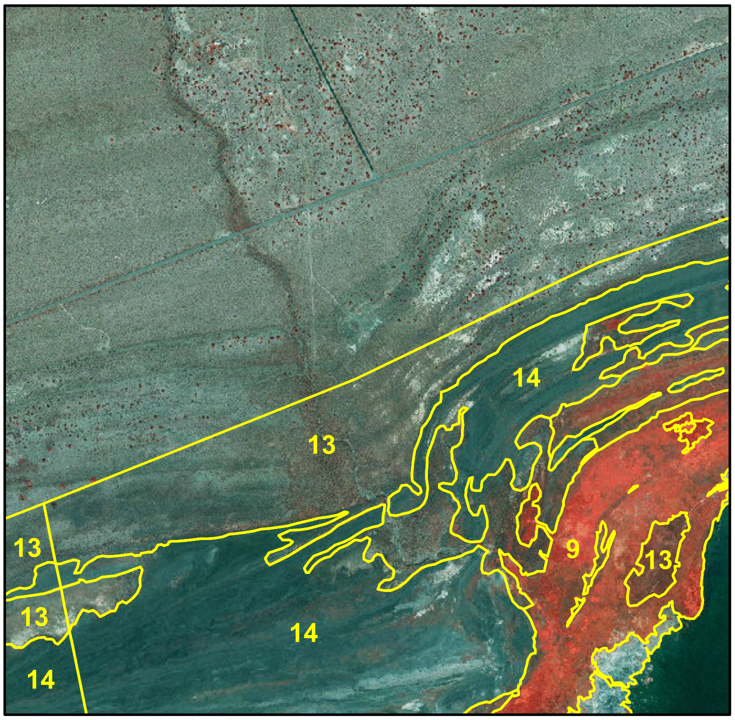
Map A5



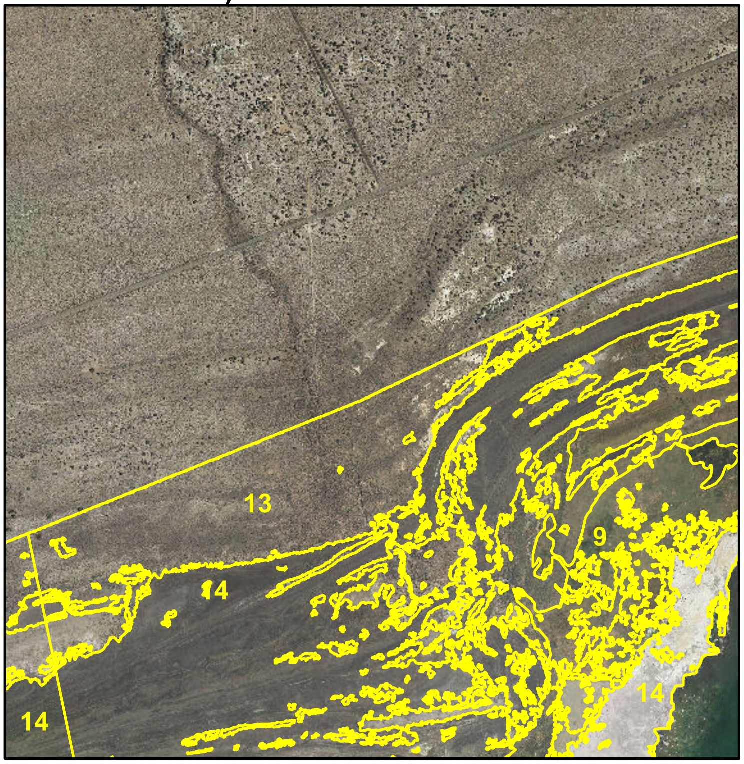


Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.

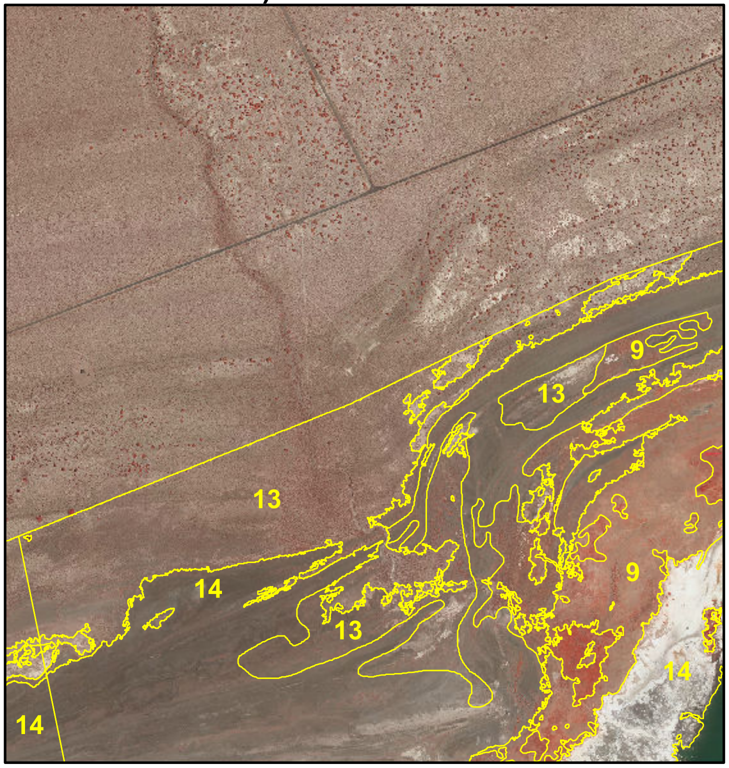
A) 1999 conditions.



B) 2005 conditions.



C) 2009 conditions.



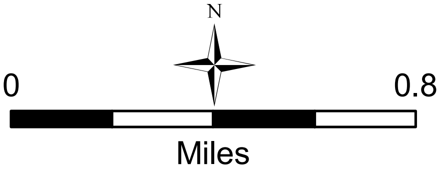
D) 2014 conditions.

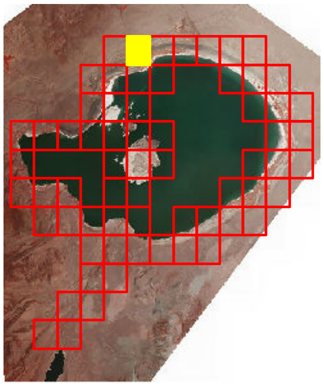
Mono Lake Landtype, Historical Conditions

Landtype Legend

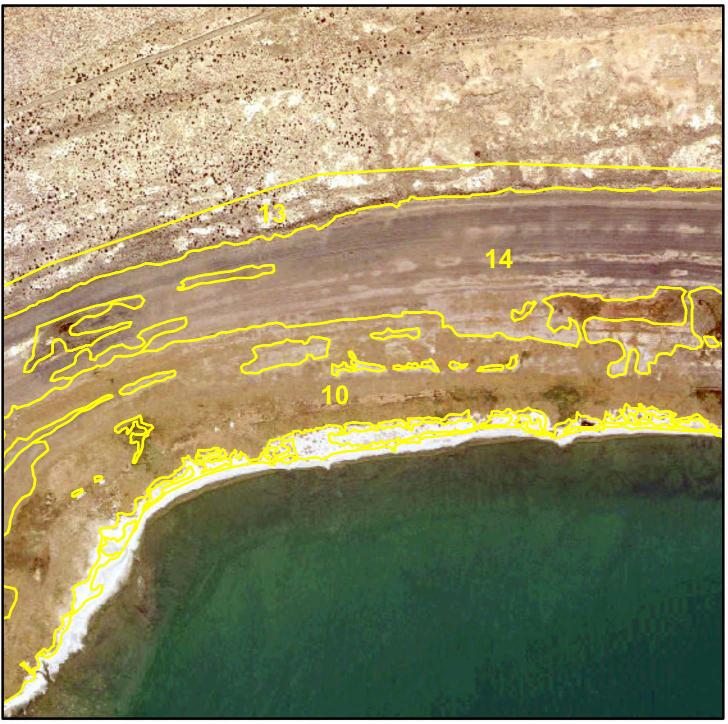
1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map A6

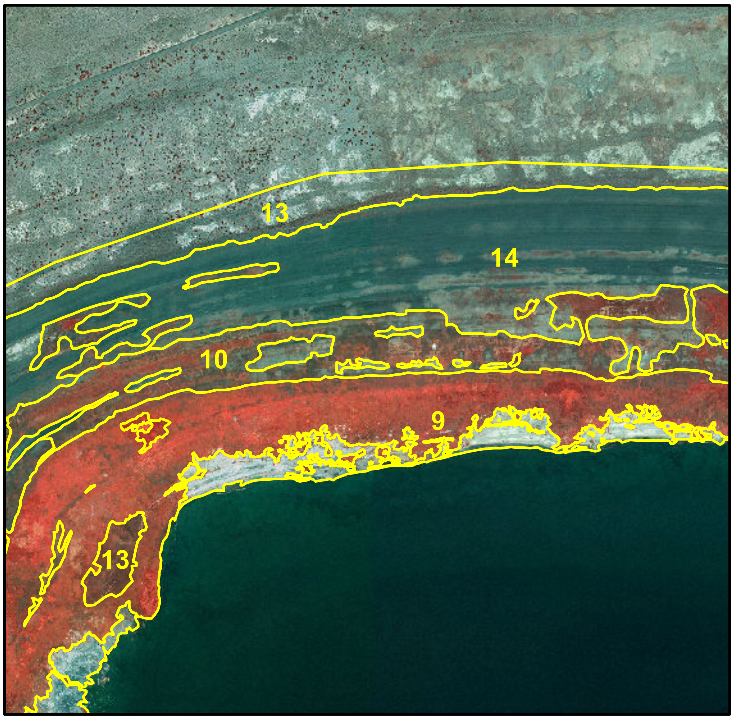




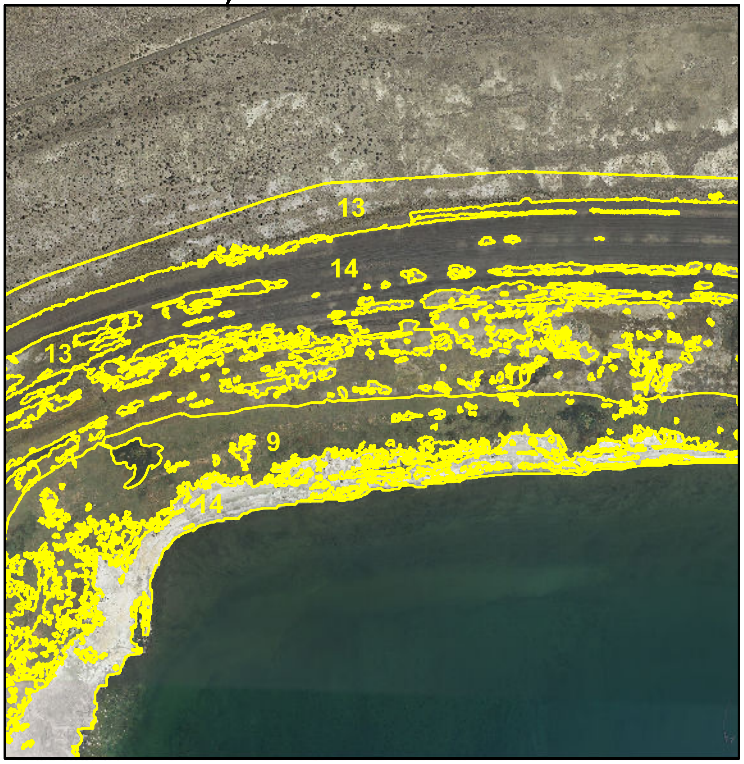
Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.



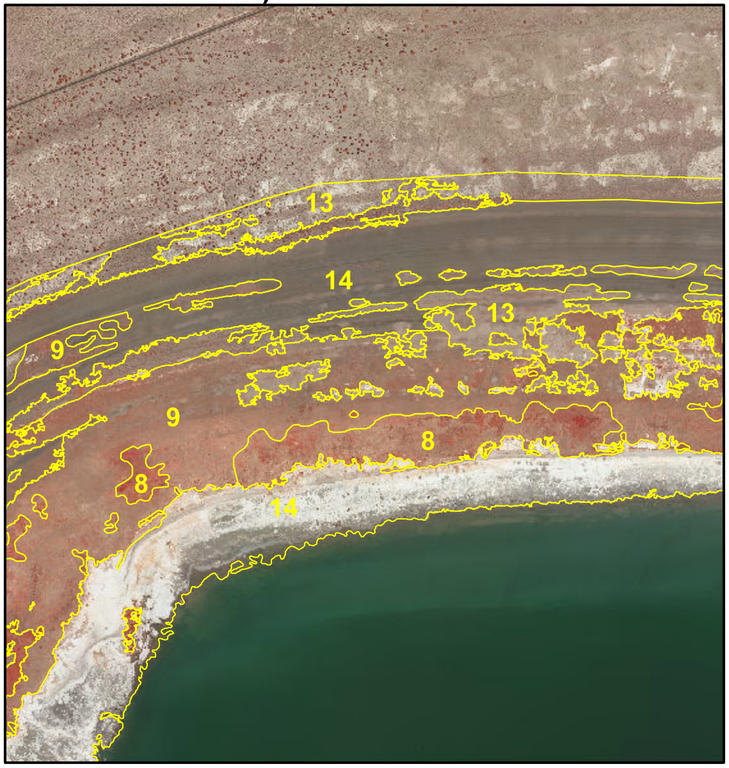
A) 1999 conditions.



B) 2005 conditions.



C) 2009 conditions.



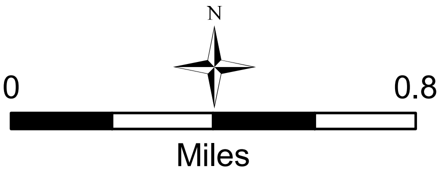
D) 2014 conditions.

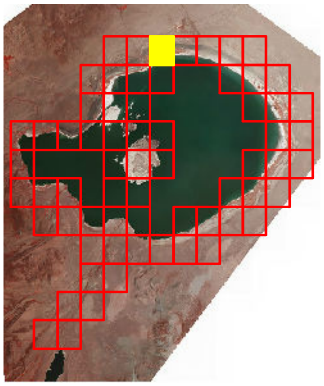
Mono Lake Landtype, Historical Conditions

Landtype Legend

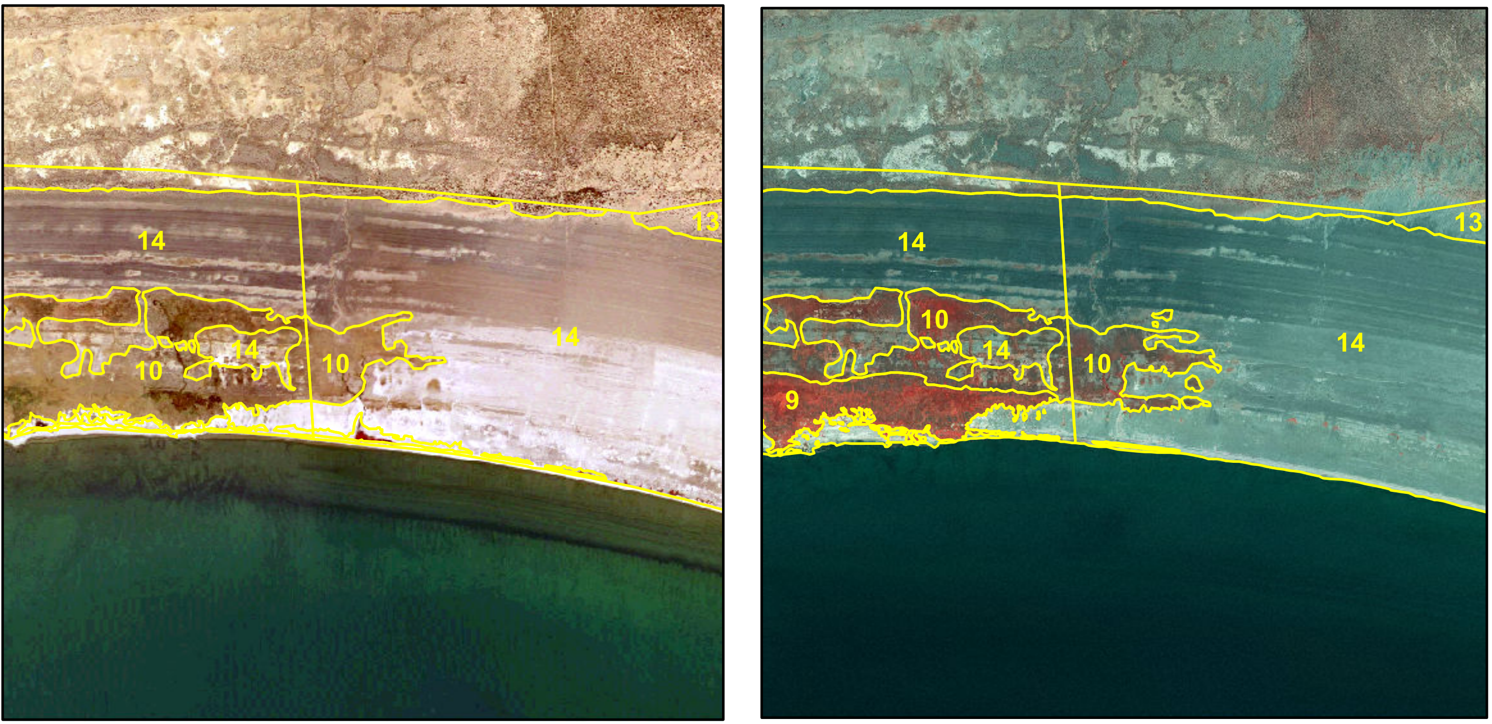
1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map A7



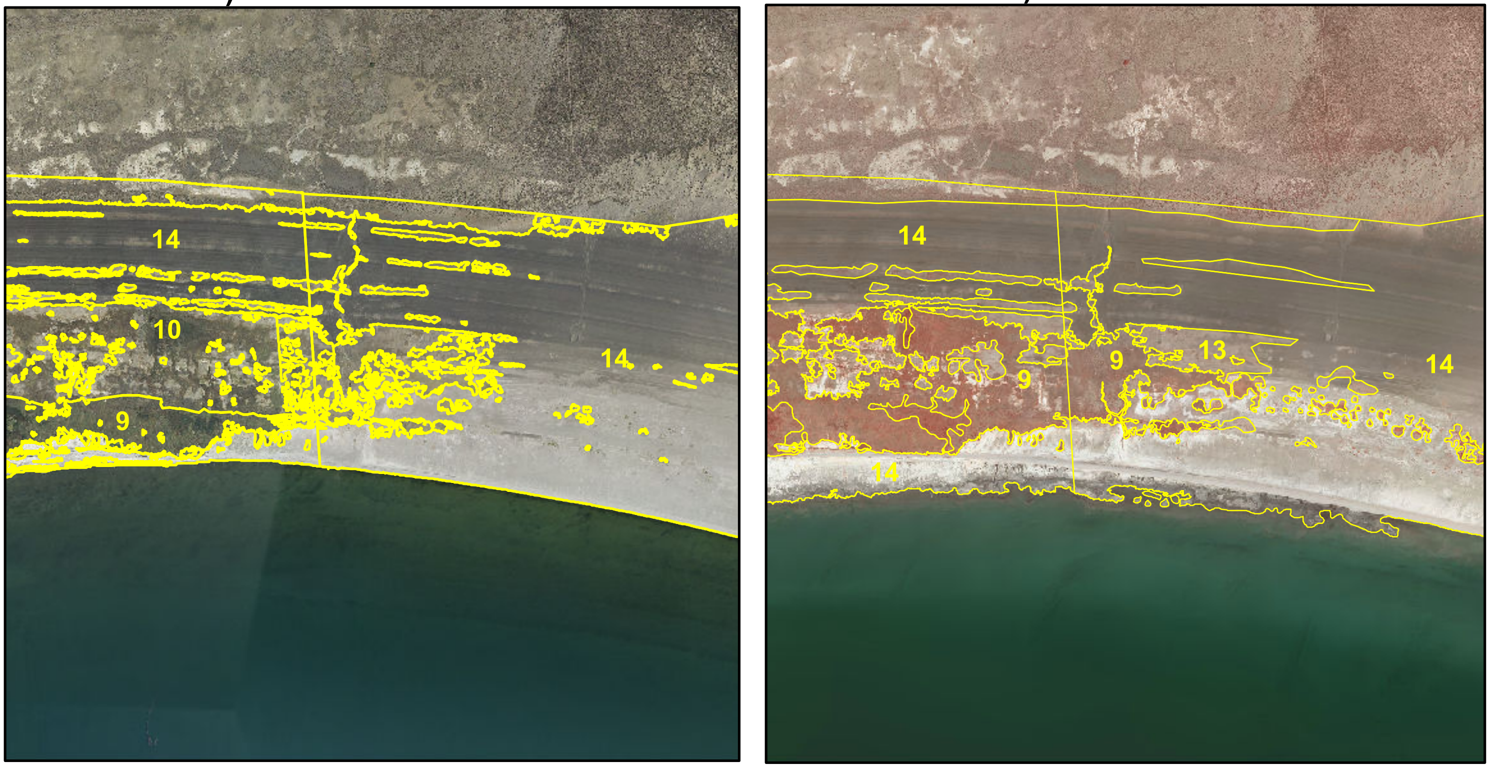


Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.



A) 1999 conditions.

B) 2005 conditions.



C) 2009 conditions.

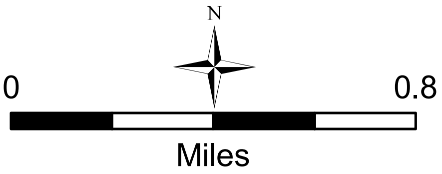
D) 2014 conditions.

Mono Lake Landtype, Historical Conditions

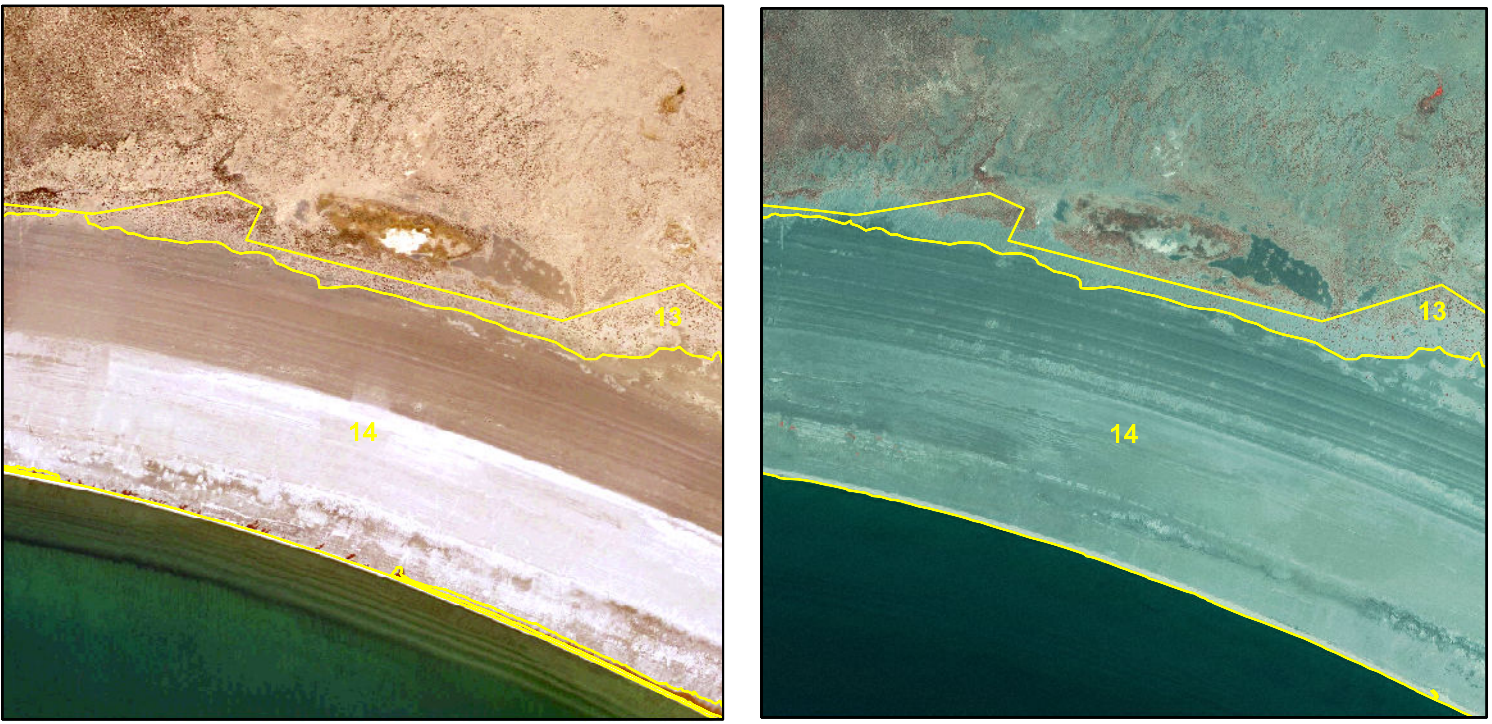
Landtype Legend

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map A8



Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.



A) 1999 conditions.

B) 2005 conditions.

C) 2009 conditions.

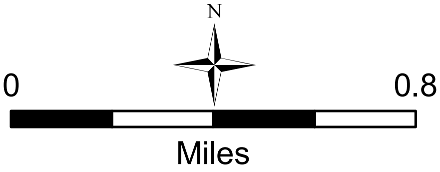
D) 2014 conditions.

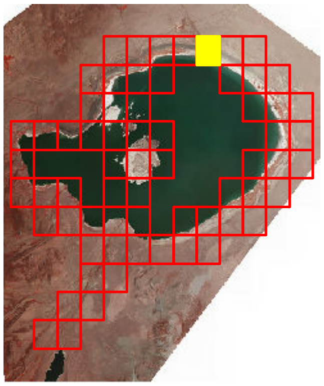
Mono Lake Landtype, Historical Conditions

Landtype Legend

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

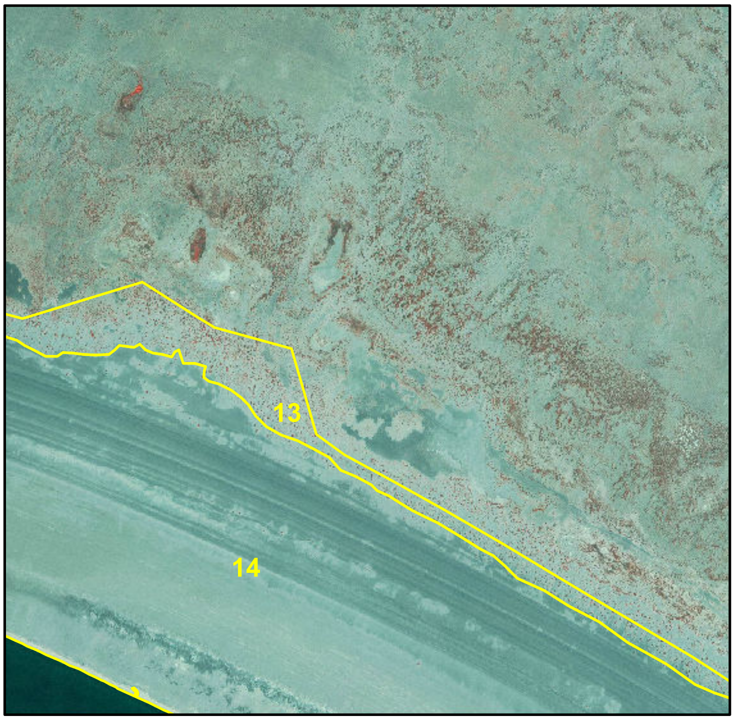
Map A9



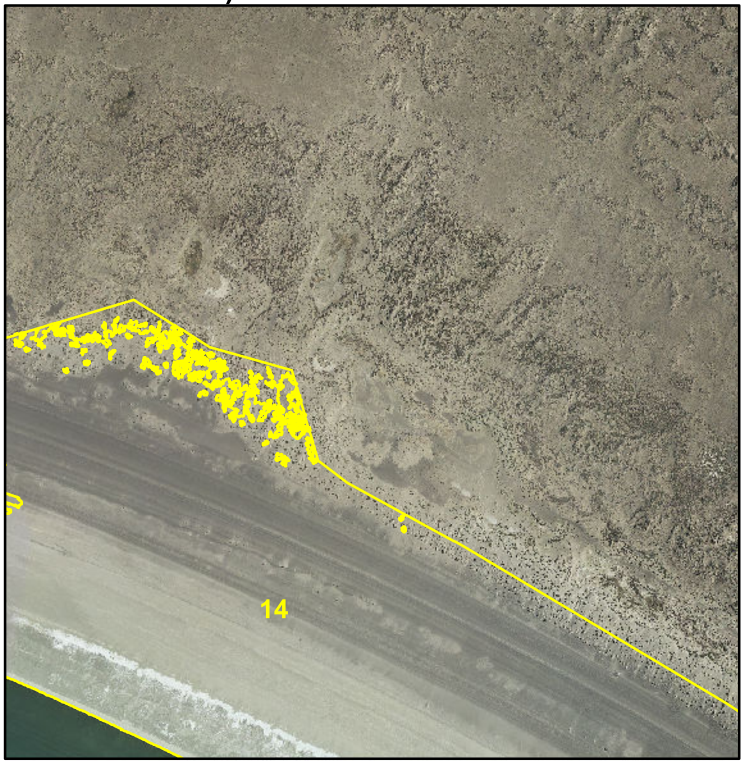


Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.

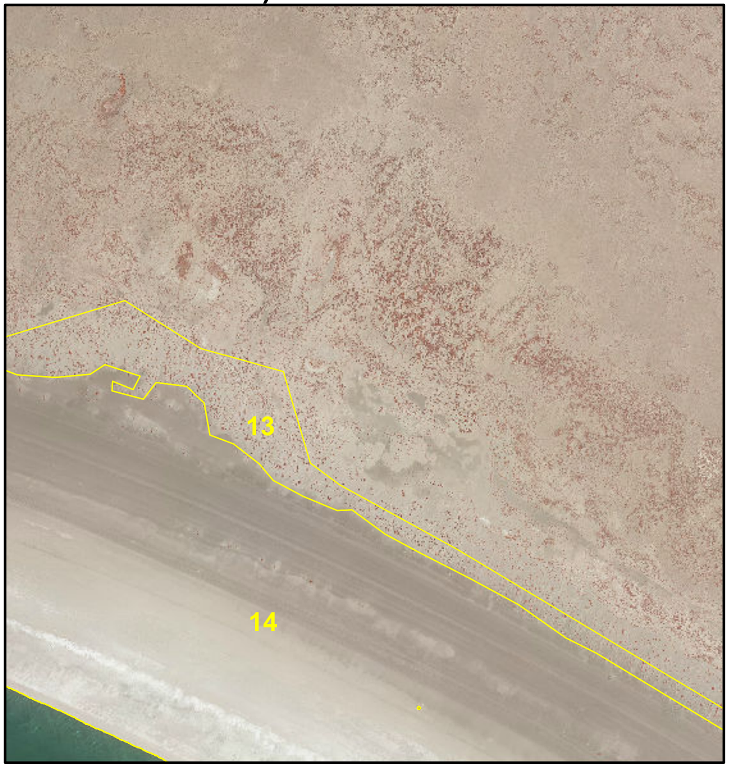
A) 1999 conditions.



B) 2005 conditions.



C) 2009 conditions.



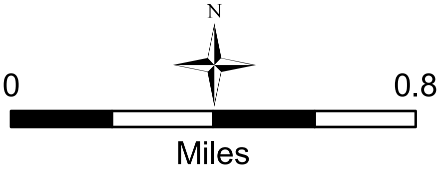
D) 2014 conditions.

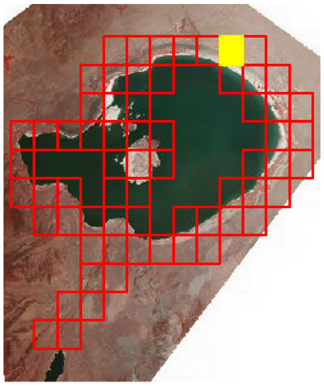
Mono Lake Landtype, Historical Conditions

Landtype Legend

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

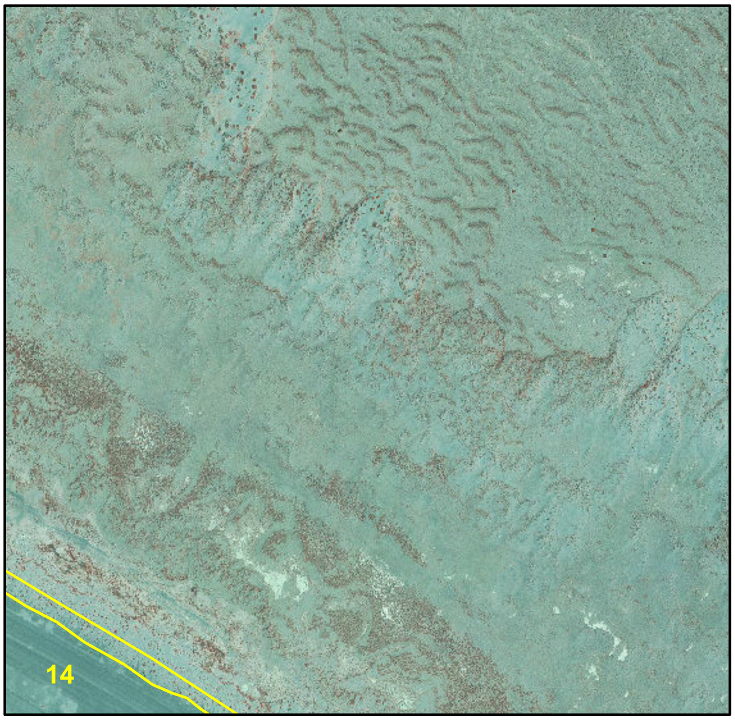
Map A10



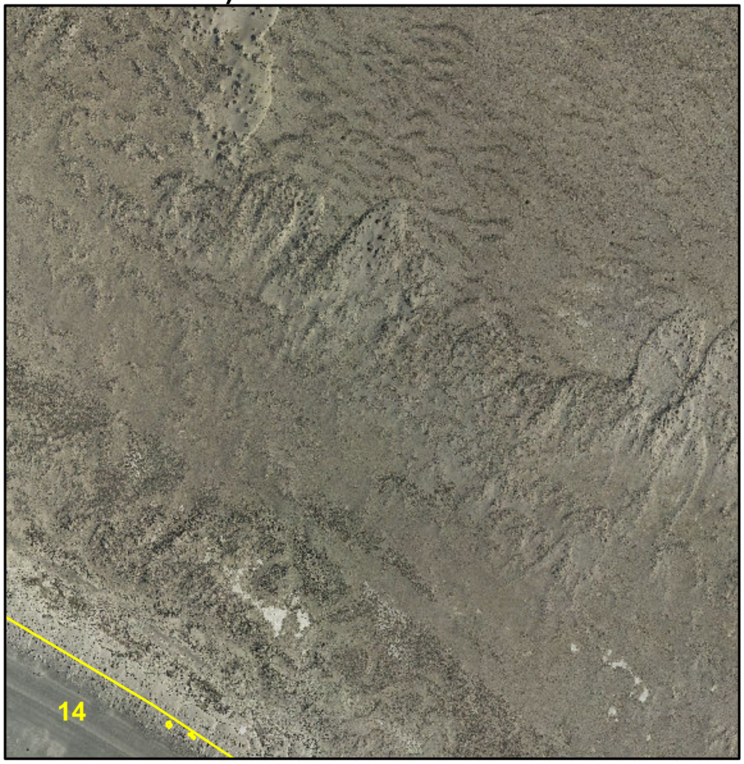


Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.

A) 1999 conditions.



B) 2005 conditions.



C) 2009 conditions.

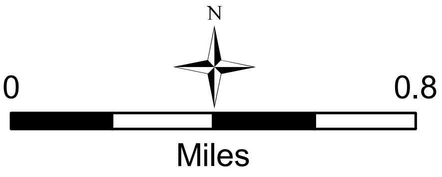
D) 2014 conditions.

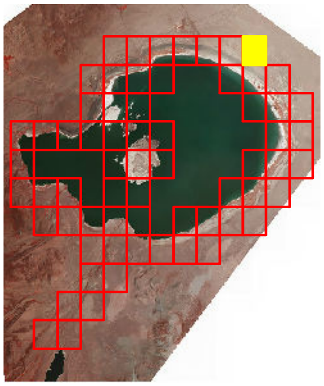
Mono Lake Landtype, Historical Conditions

Landtype Legend

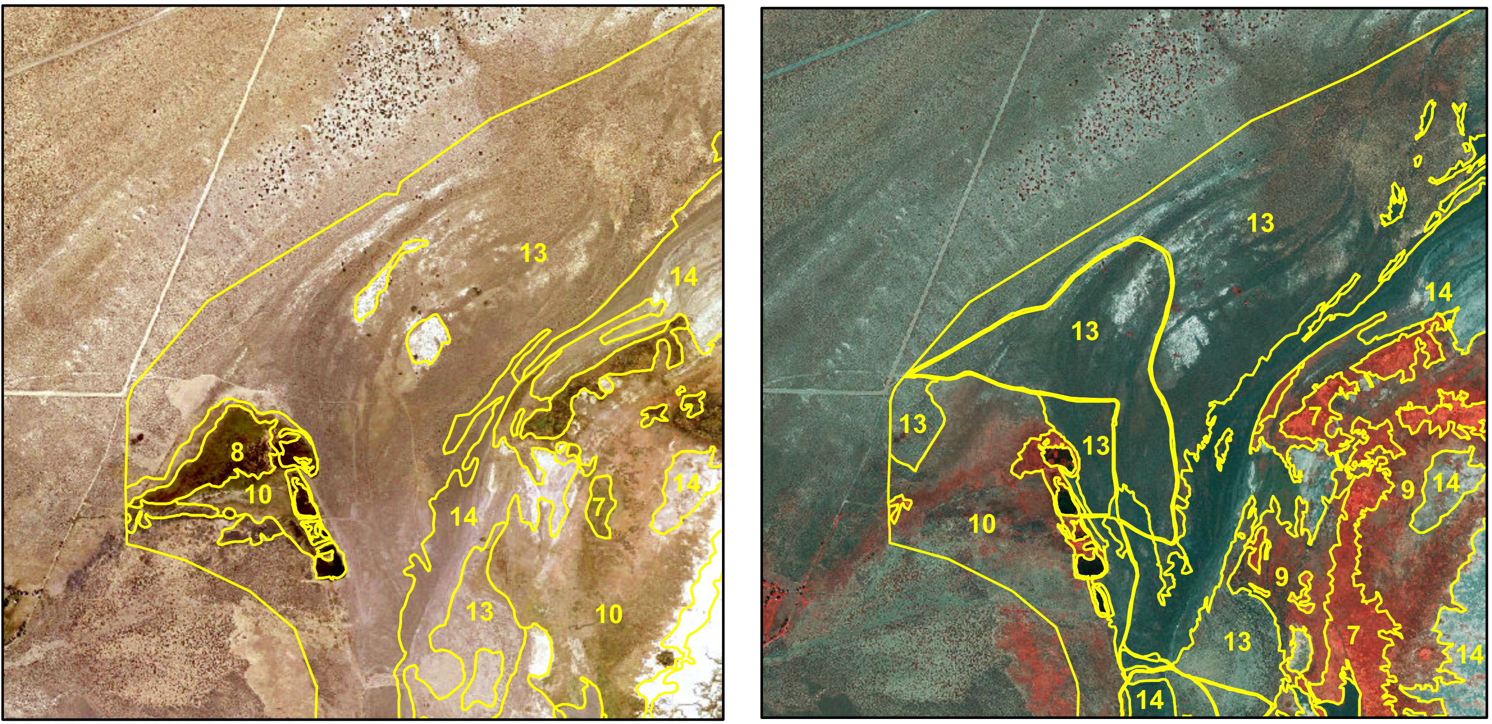
1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map A11



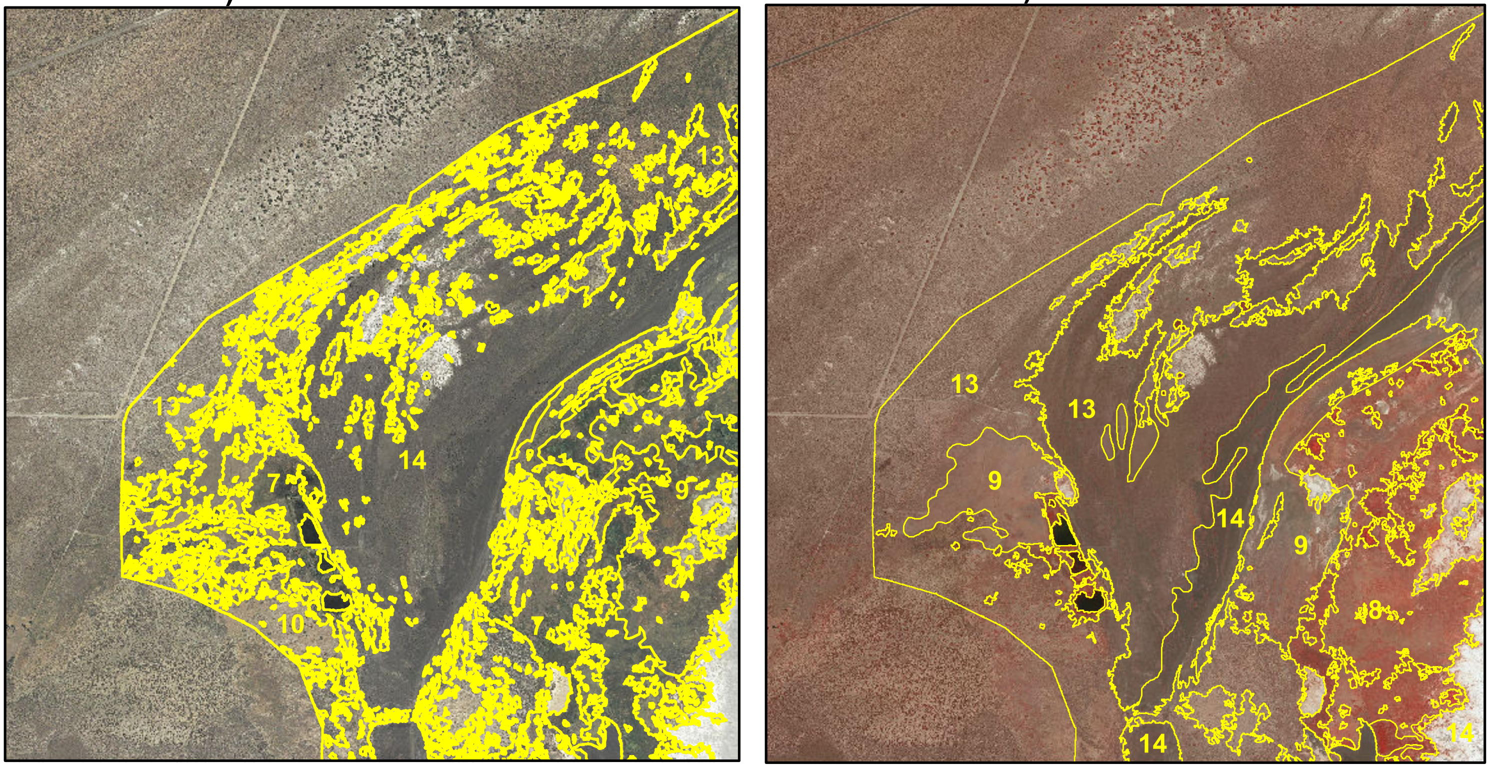


Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.



A) 1999 conditions.

B) 2005 conditions.



C) 2009 conditions.

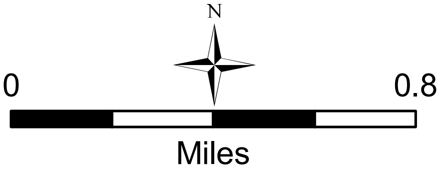
D) 2014 conditions.

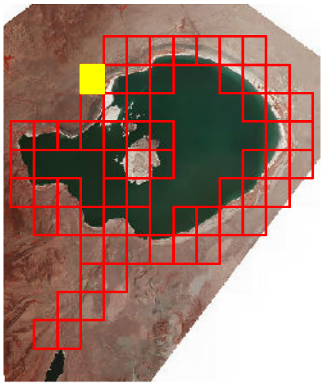
Mono Lake Landtype, Historical Conditions

Landtype Legend

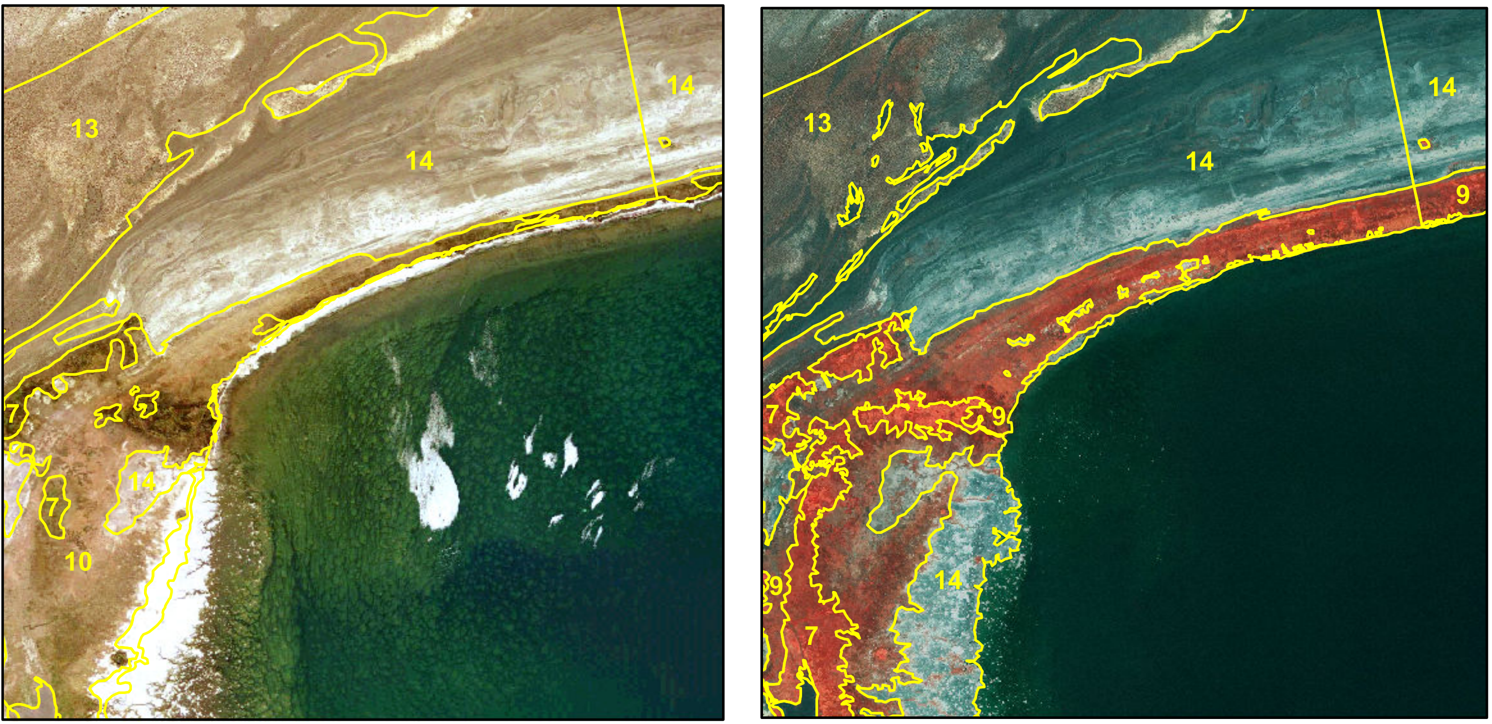
1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map B4



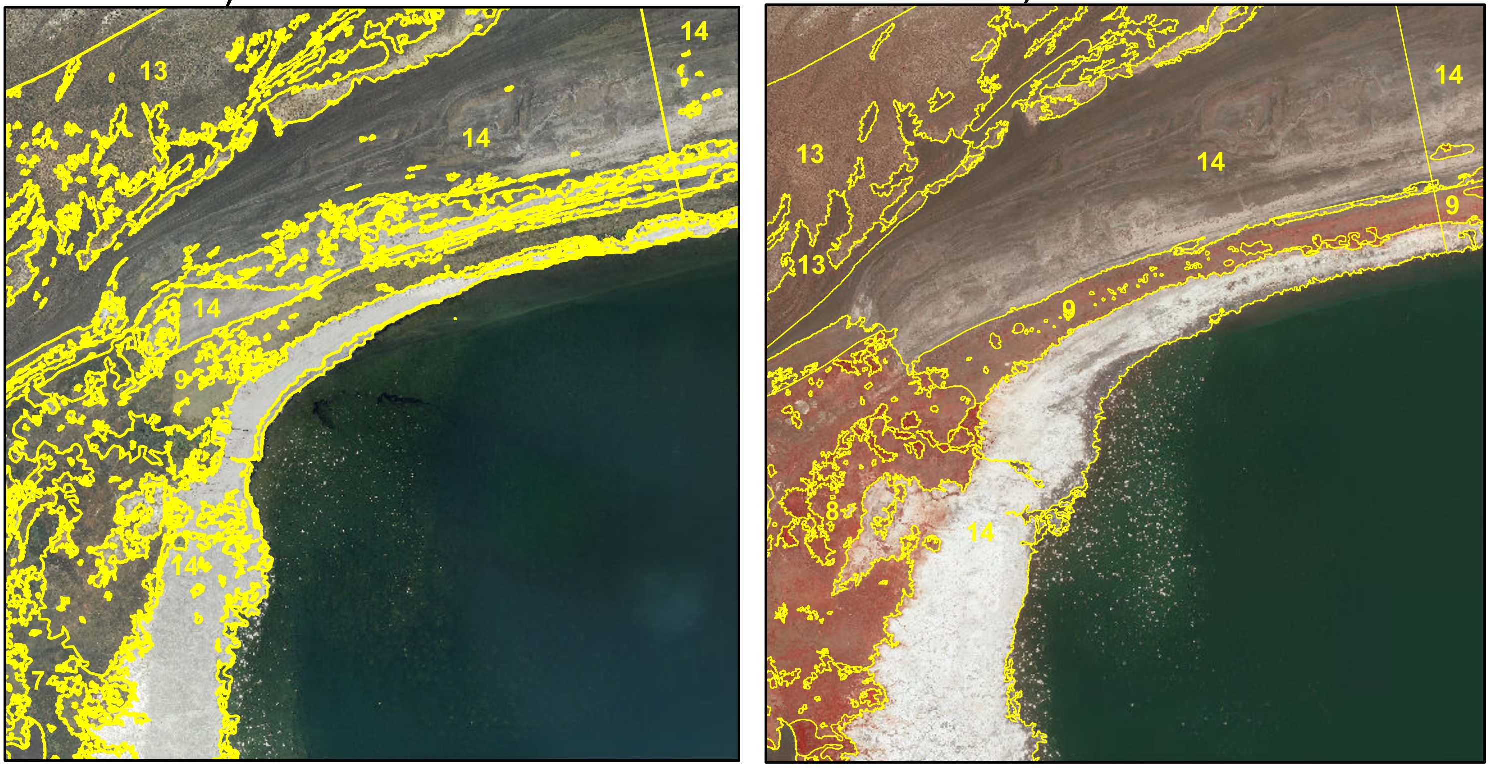


Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.



A) 1999 conditions.

B) 2005 conditions.



C) 2009 conditions.

D) 2014 conditions.

Mono Lake Landtype, Historical Conditions

Landtype Legend

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map B5

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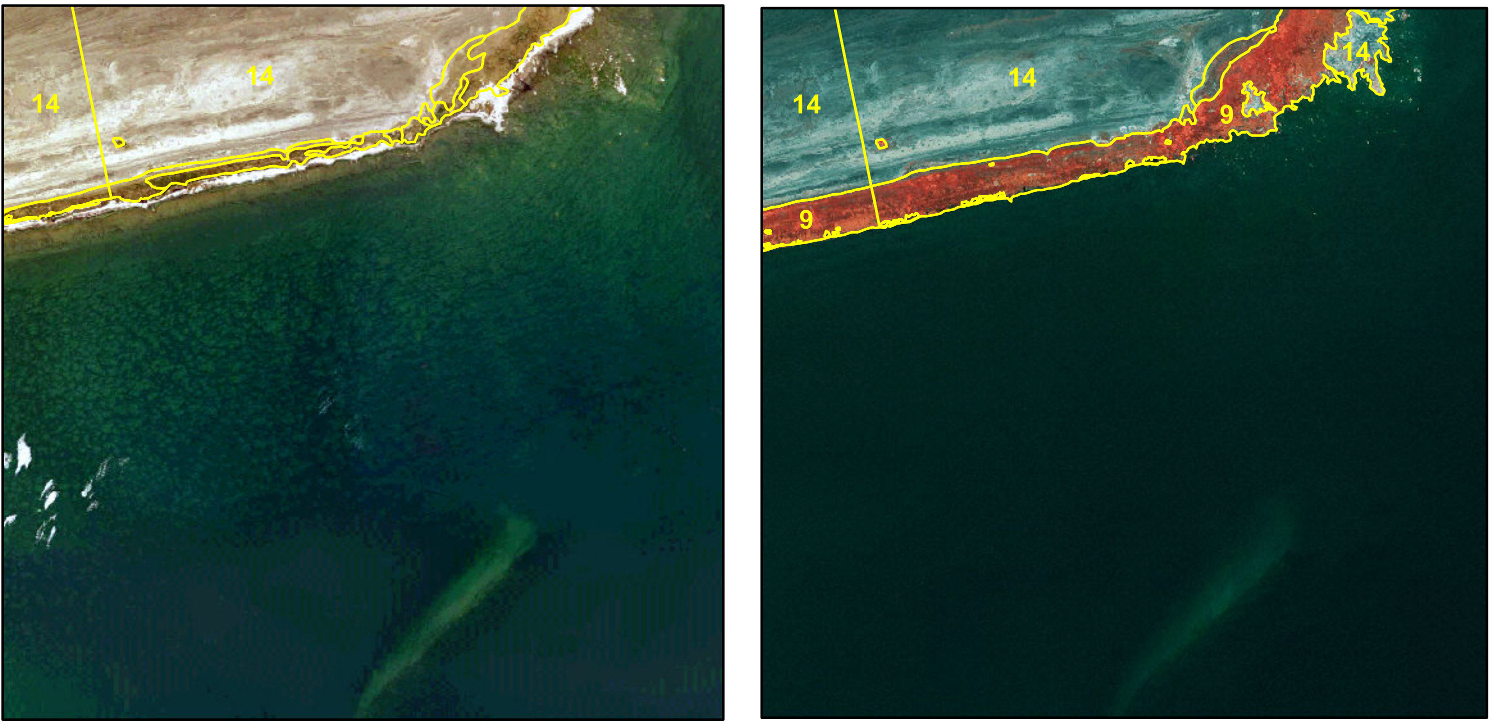
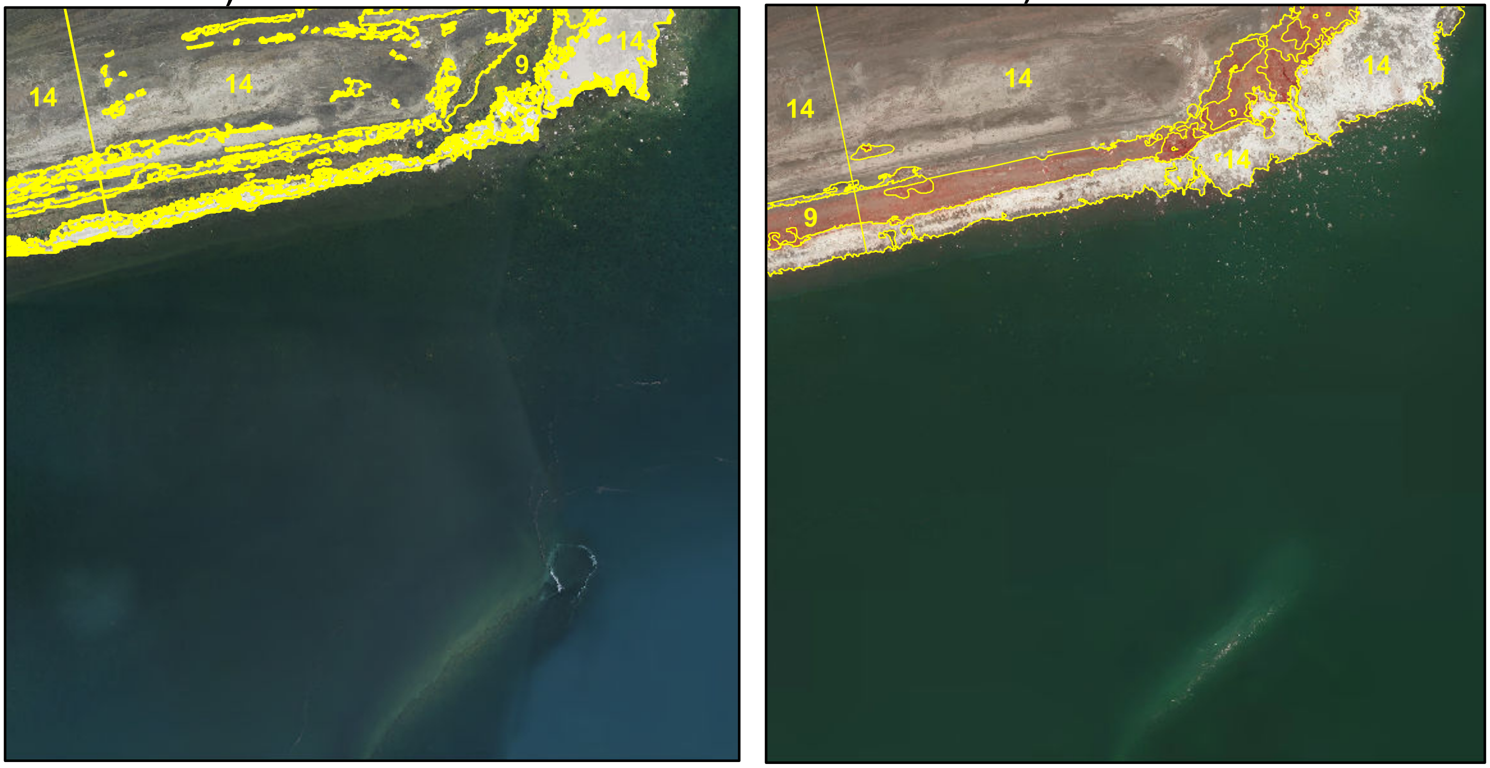
Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.



A) 1999 conditions.

B) 2005 conditions.



C) 2009 conditions.

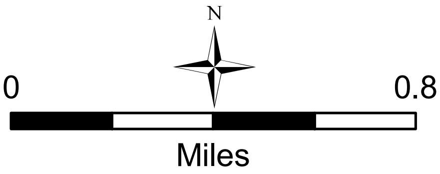
D) 2014 conditions.

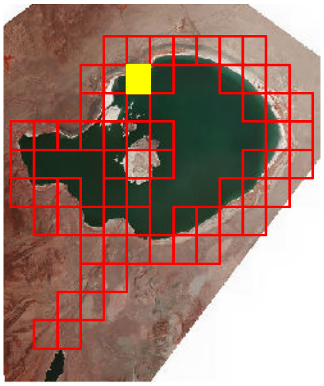
Mono Lake Landtype, Historical Conditions

Landtype Legend

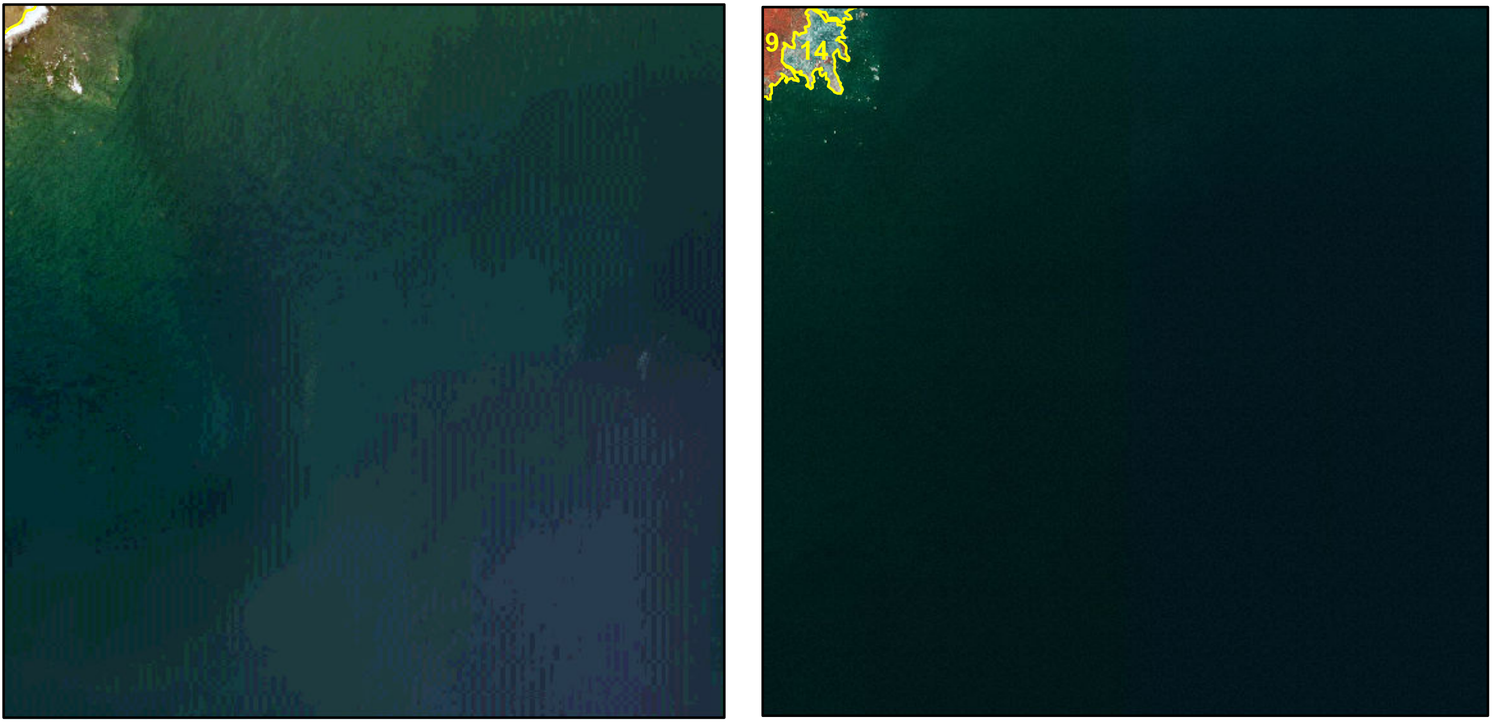
1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map B6



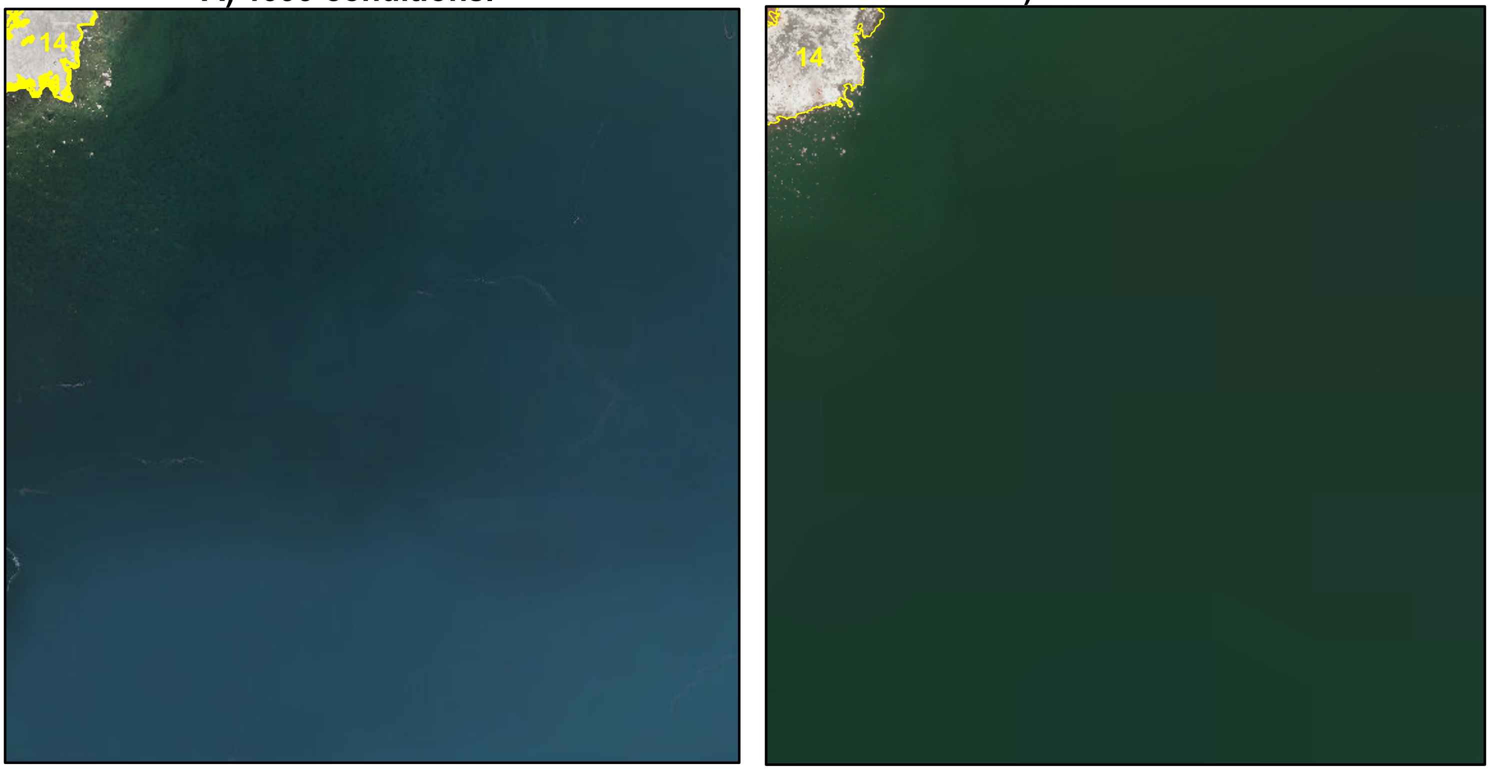


Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.



A) 1999 conditions.

B) 2005 conditions.



C) 2009 conditions.

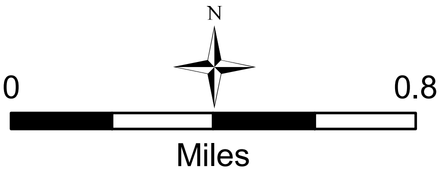
D) 2014 conditions.

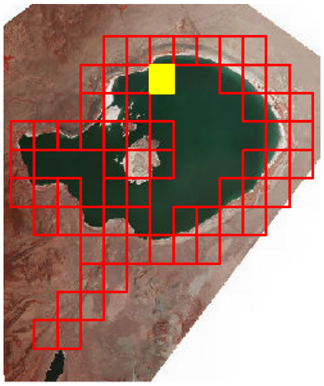
Mono Lake Landtype, Historical Conditions

Landtype Legend

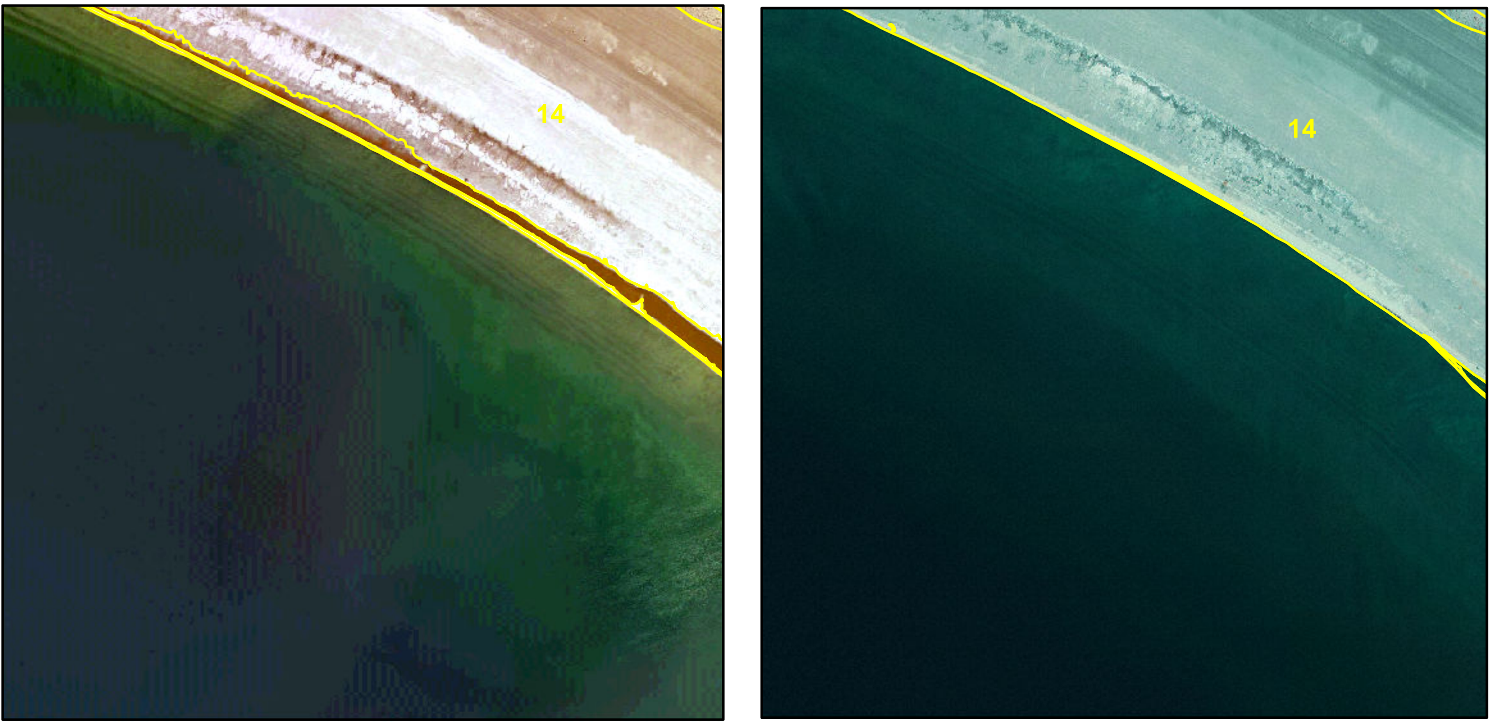
1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map B7



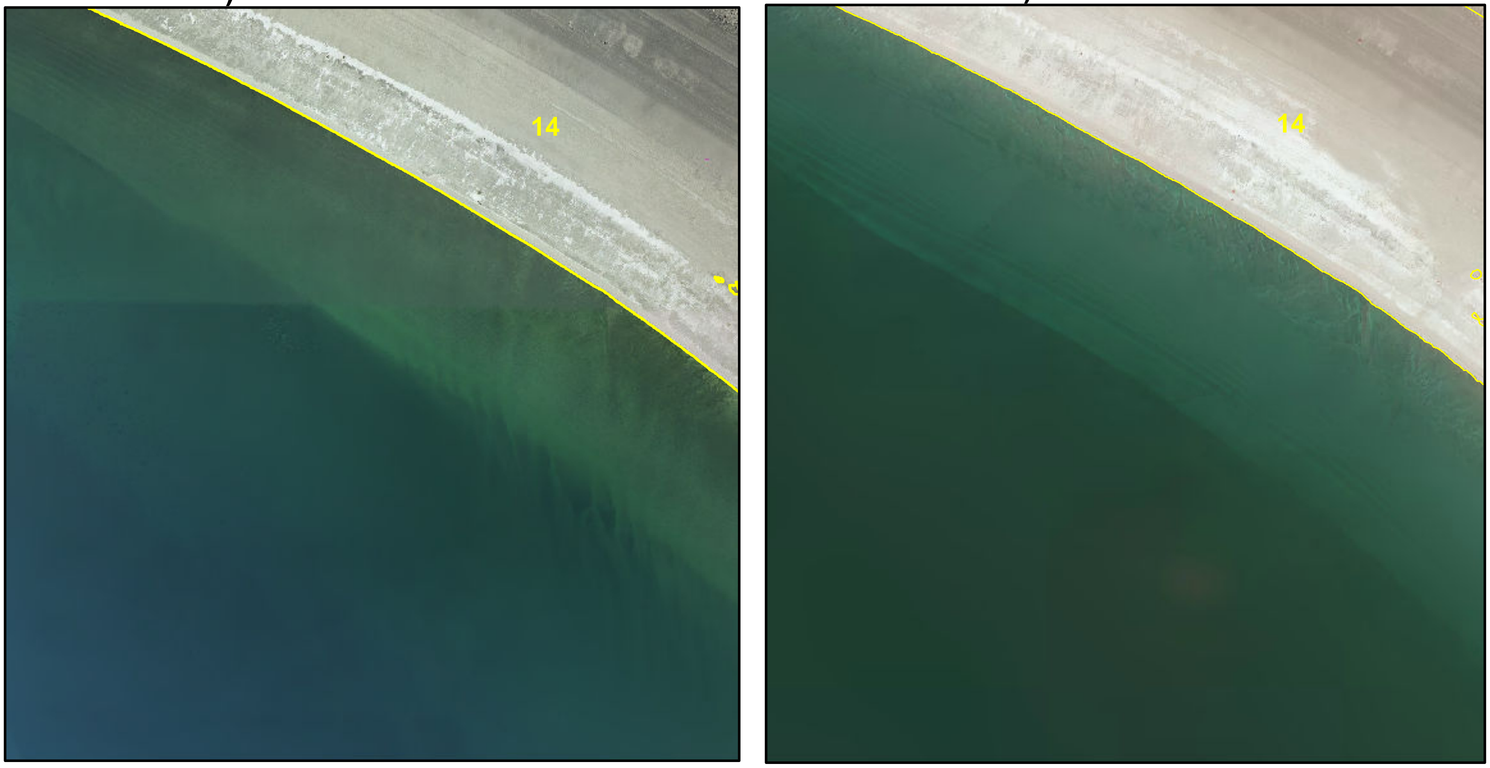


Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.



A) 1999 conditions.

B) 2005 conditions.



C) 2009 conditions.

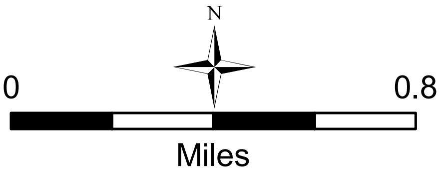
D) 2014 conditions.

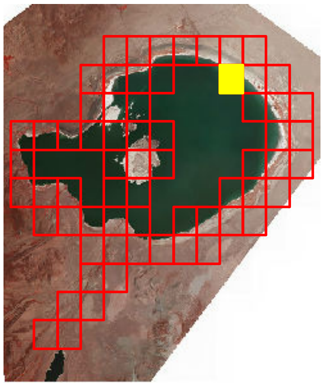
Mono Lake Landtype, Historical Conditions

Landtype Legend

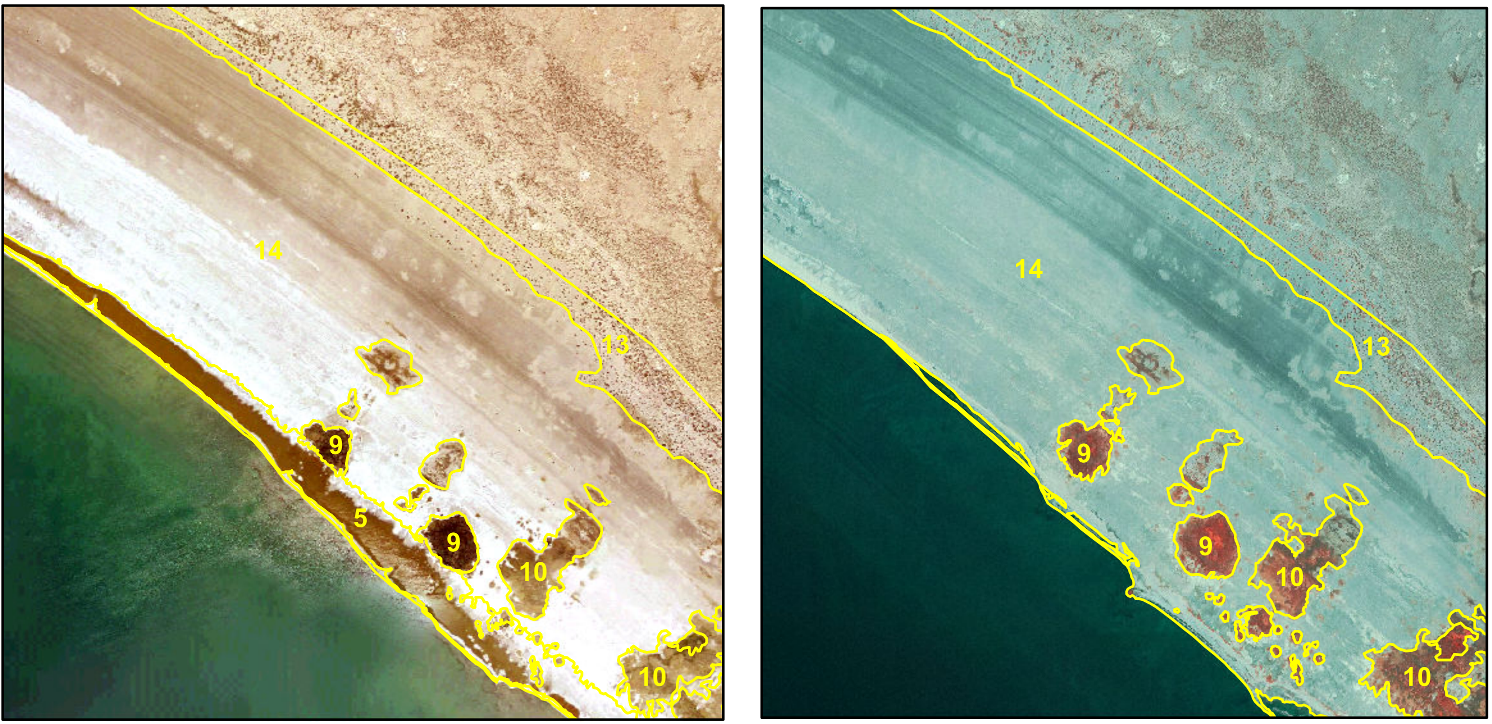
1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map B10



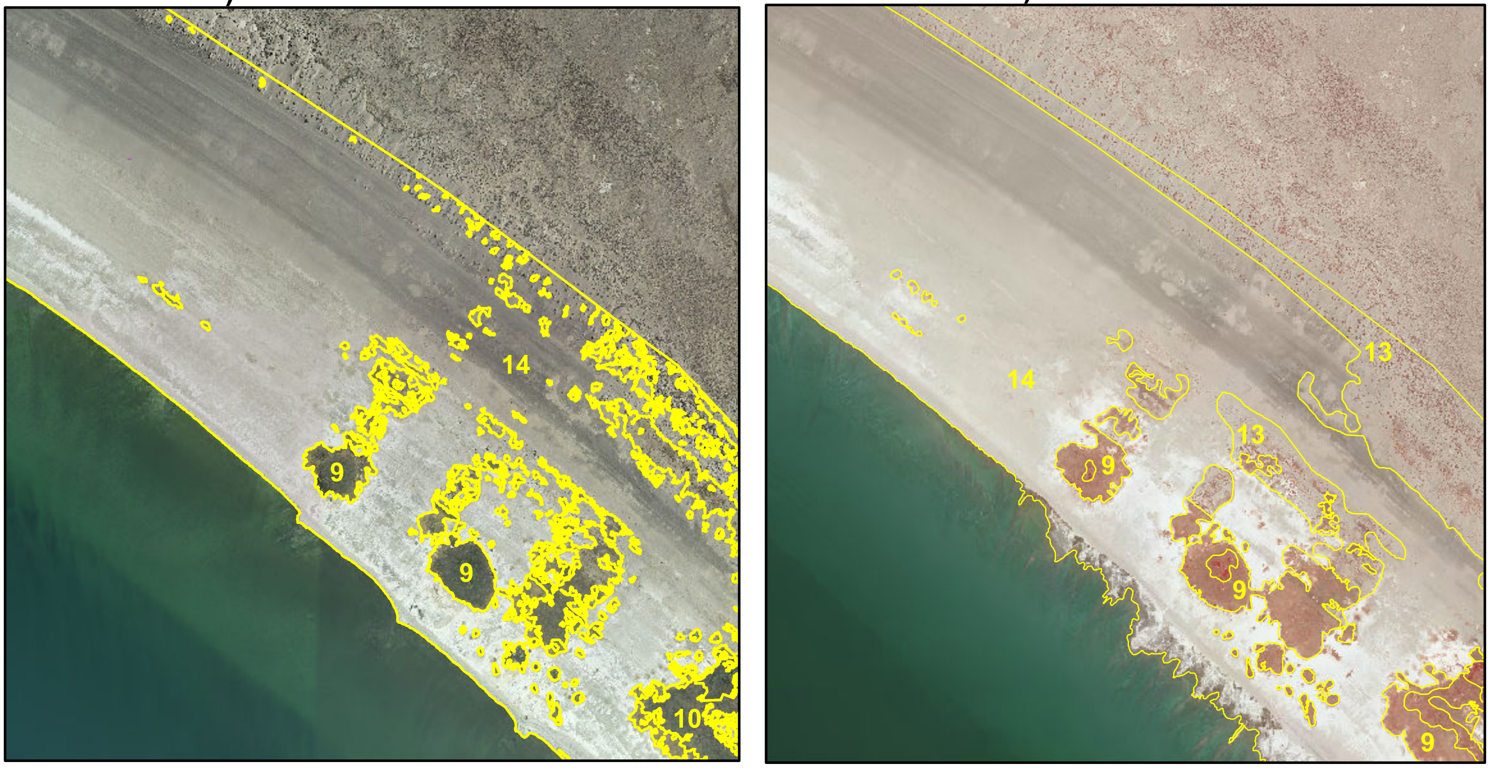


Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.



A) 1999 conditions.

B) 2005 conditions.



C) 2009 conditions.

D) 2014 conditions.

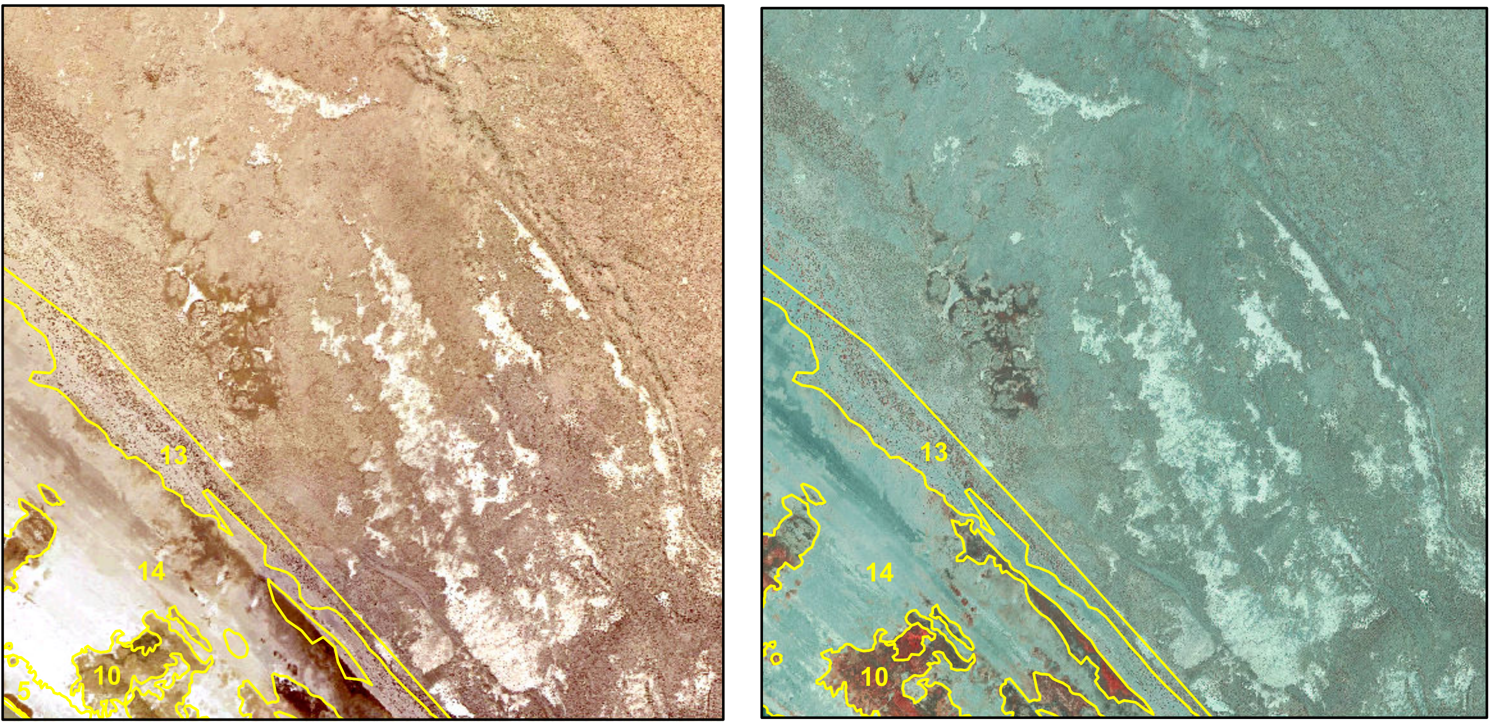
Mono Lake Landtype, Historical Conditions

Landtype Legend

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

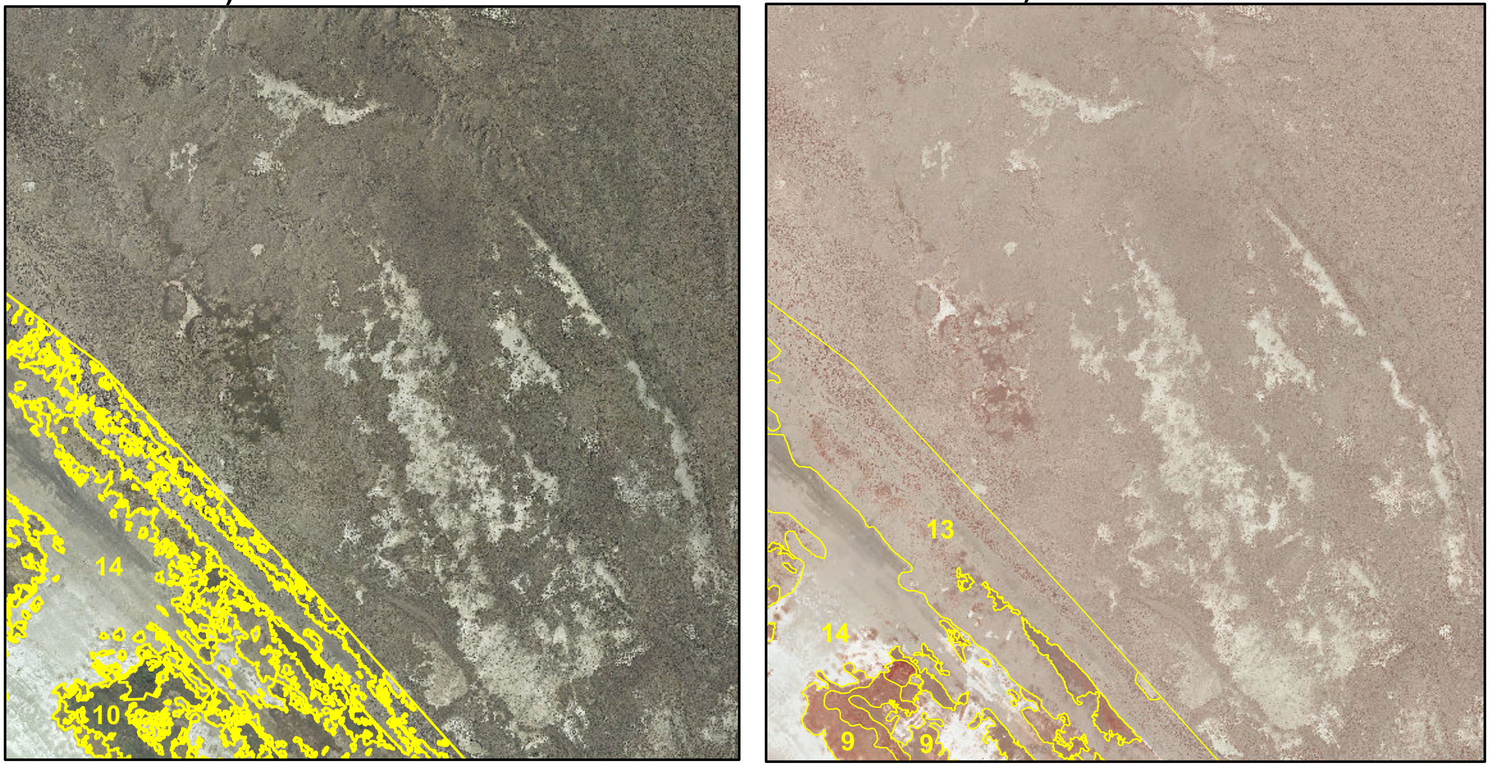
Map B11

Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.



A) 1999 conditions.

B) 2005 conditions.



C) 2009 conditions.

D) 2014 conditions.

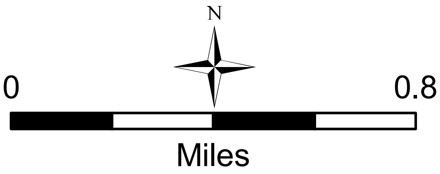
Mono Lake Landtype, Historical Conditions

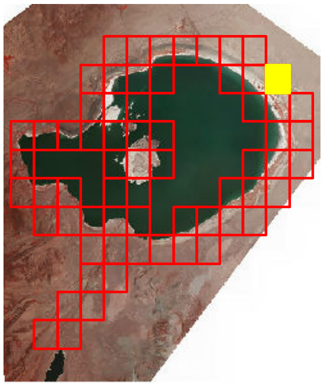
Landtype Legend

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow

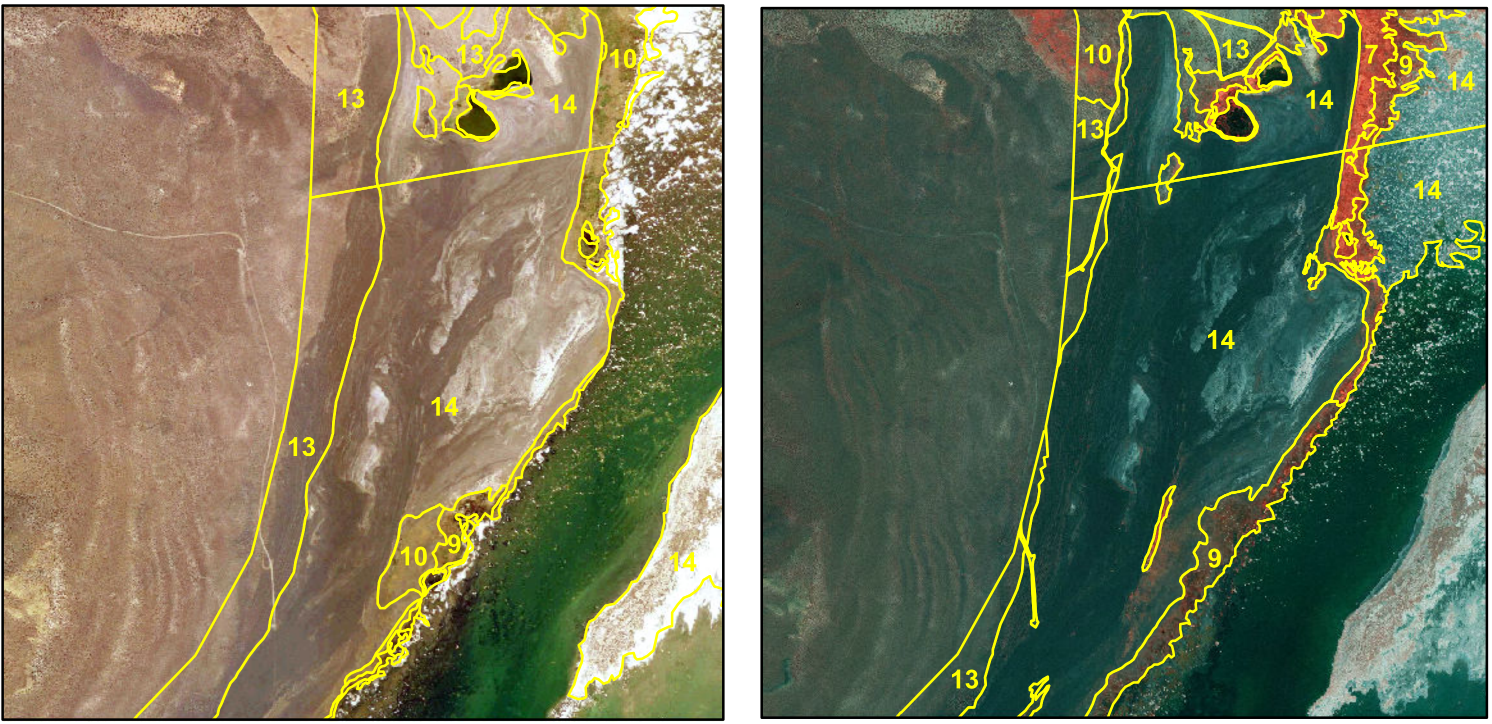
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map B12



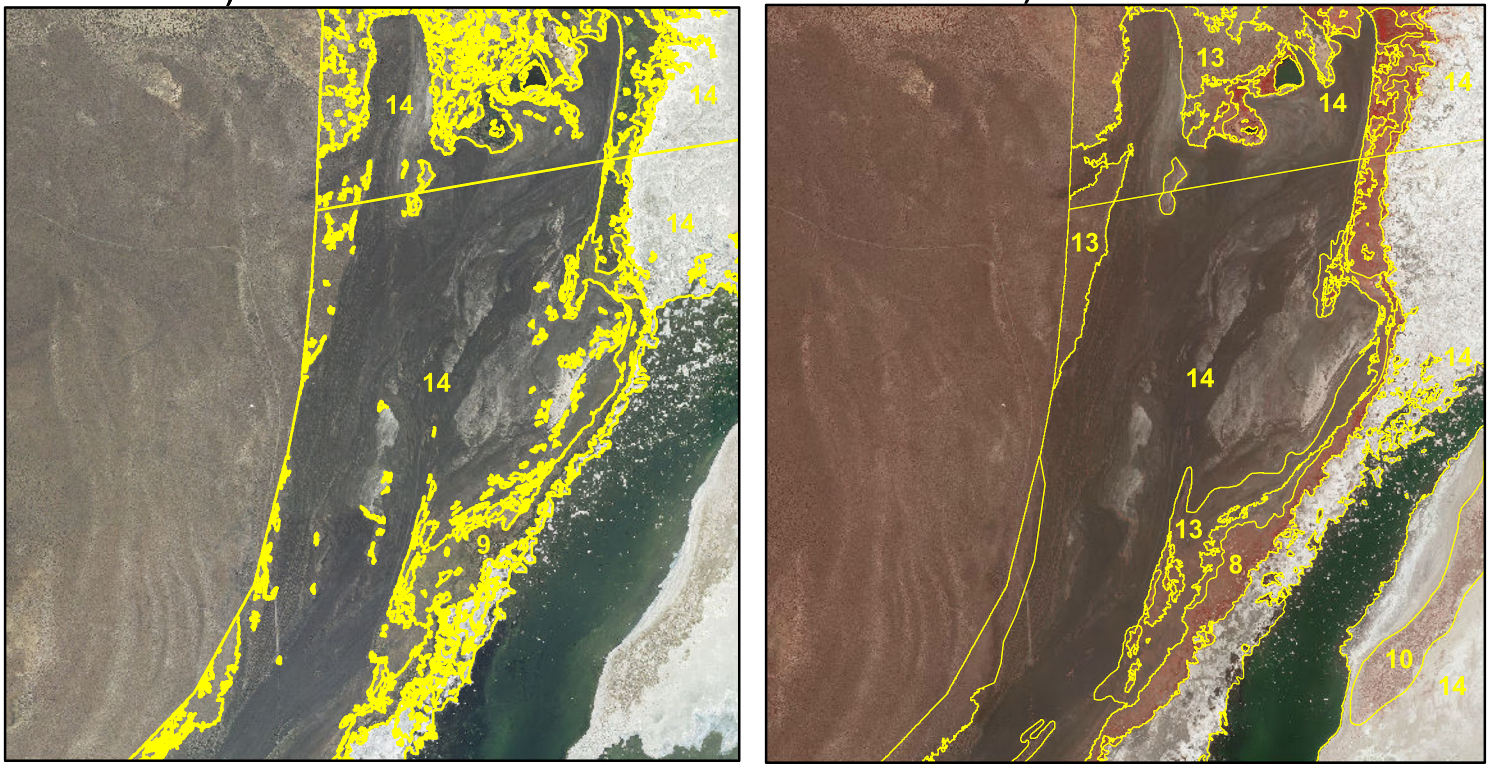


Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.



A) 1999 conditions.

B) 2005 conditions.



C) 2009 conditions.

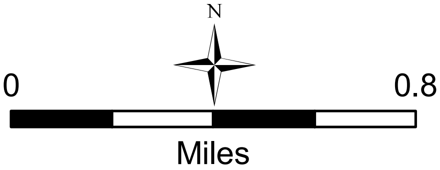
D) 2014 conditions.

Mono Lake Landtype, Historical Conditions

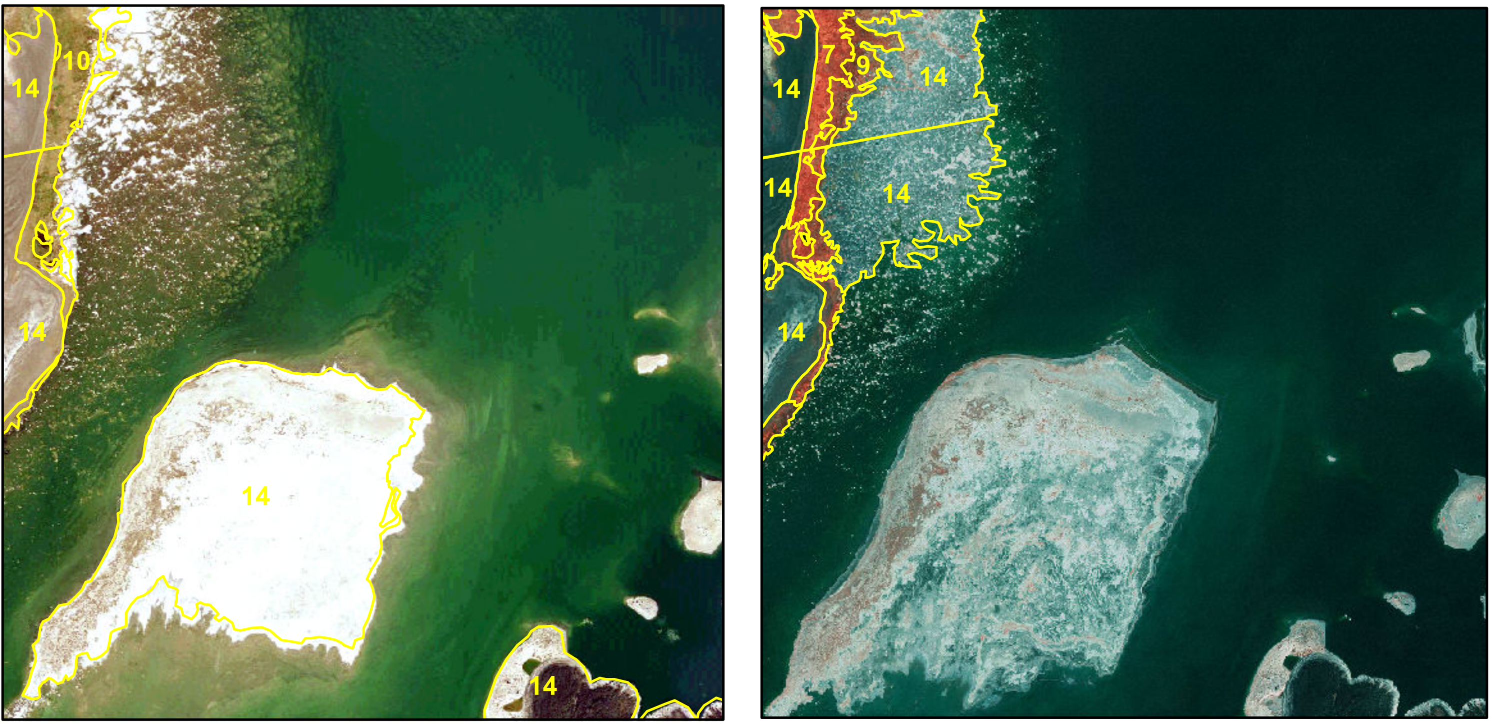
Landtype Legend

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map C4

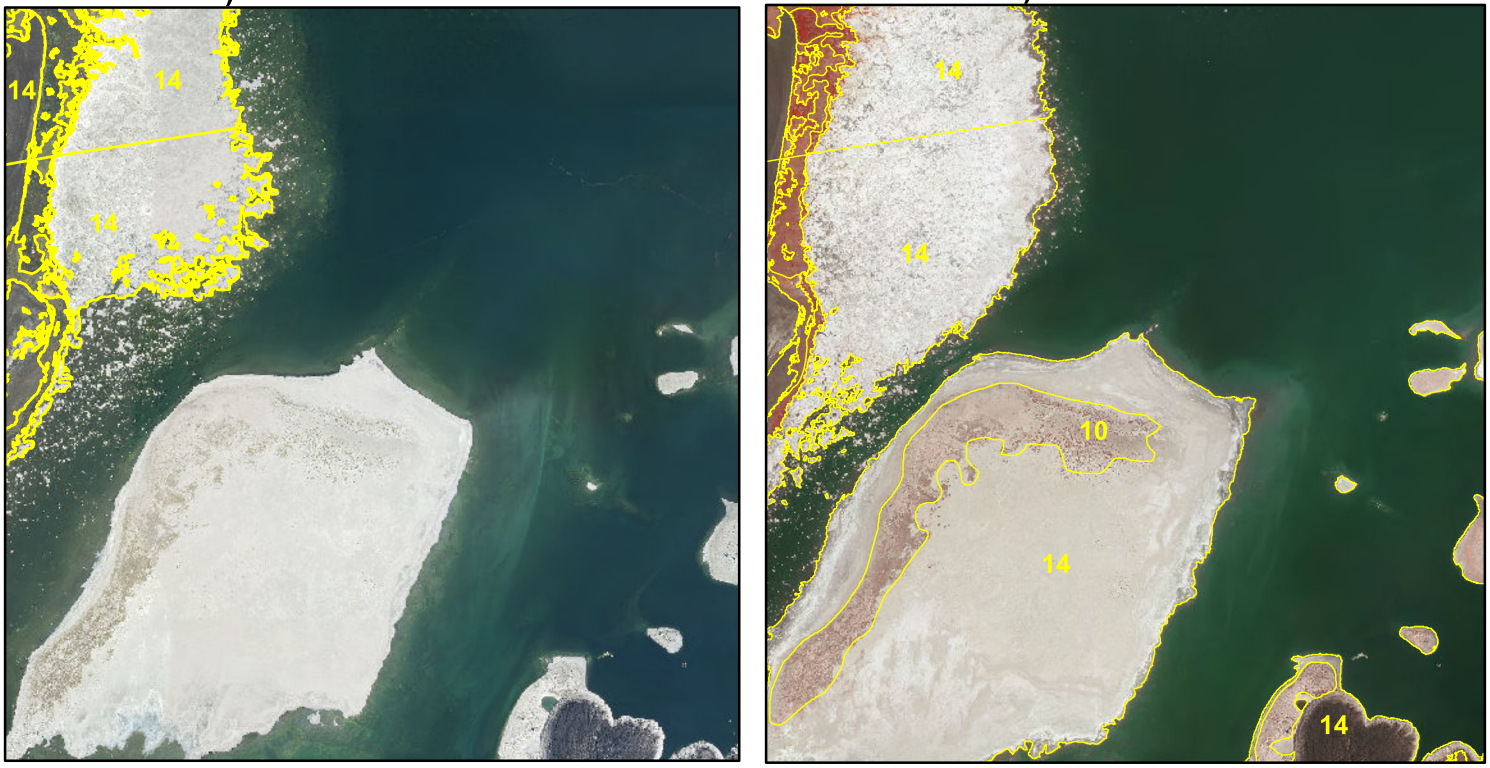


Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.



A) 1999 conditions.

B) 2005 conditions.



C) 2009 conditions.

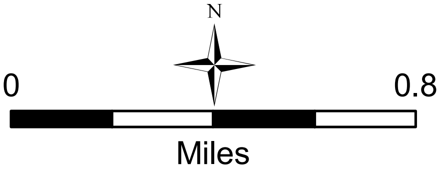
D) 2014 conditions.

Mono Lake Landtype, Historical Conditions

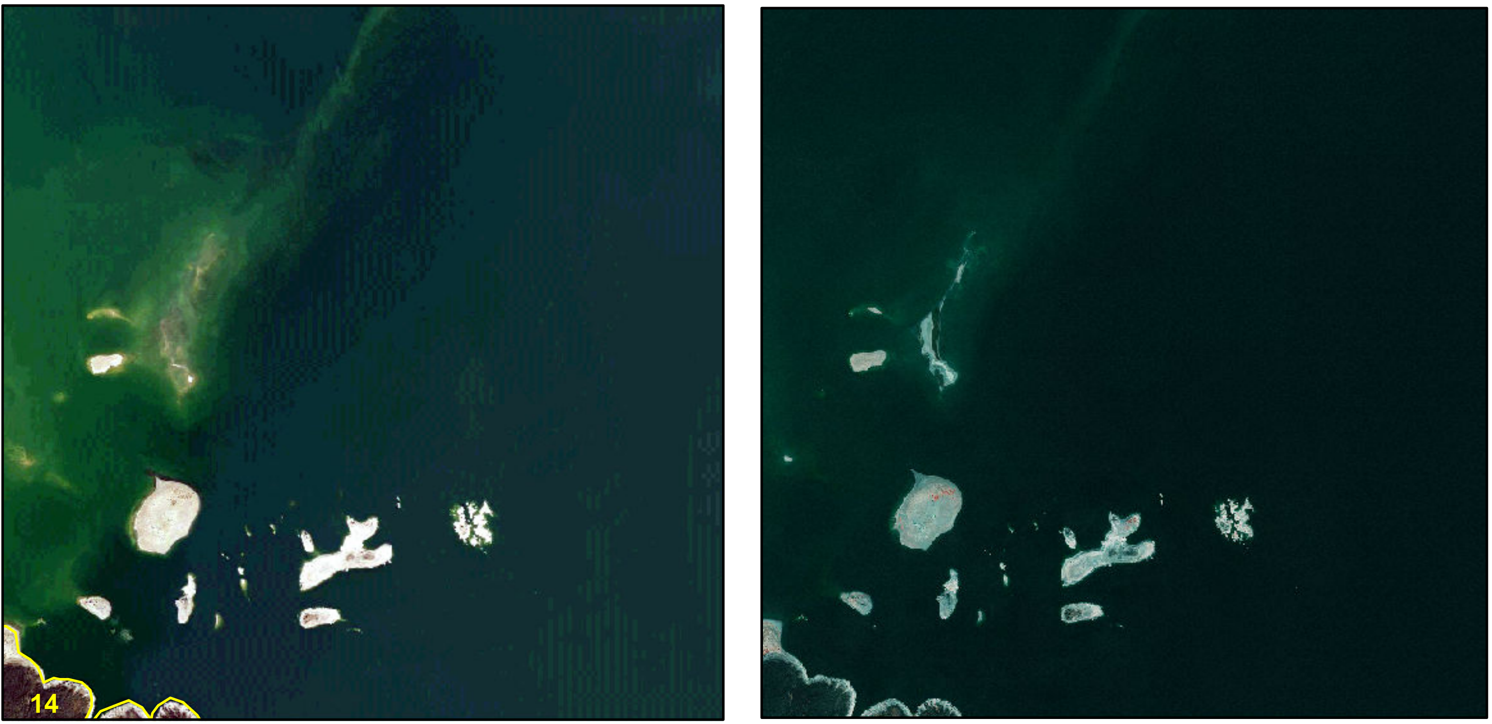
Landtype Legend

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map C5

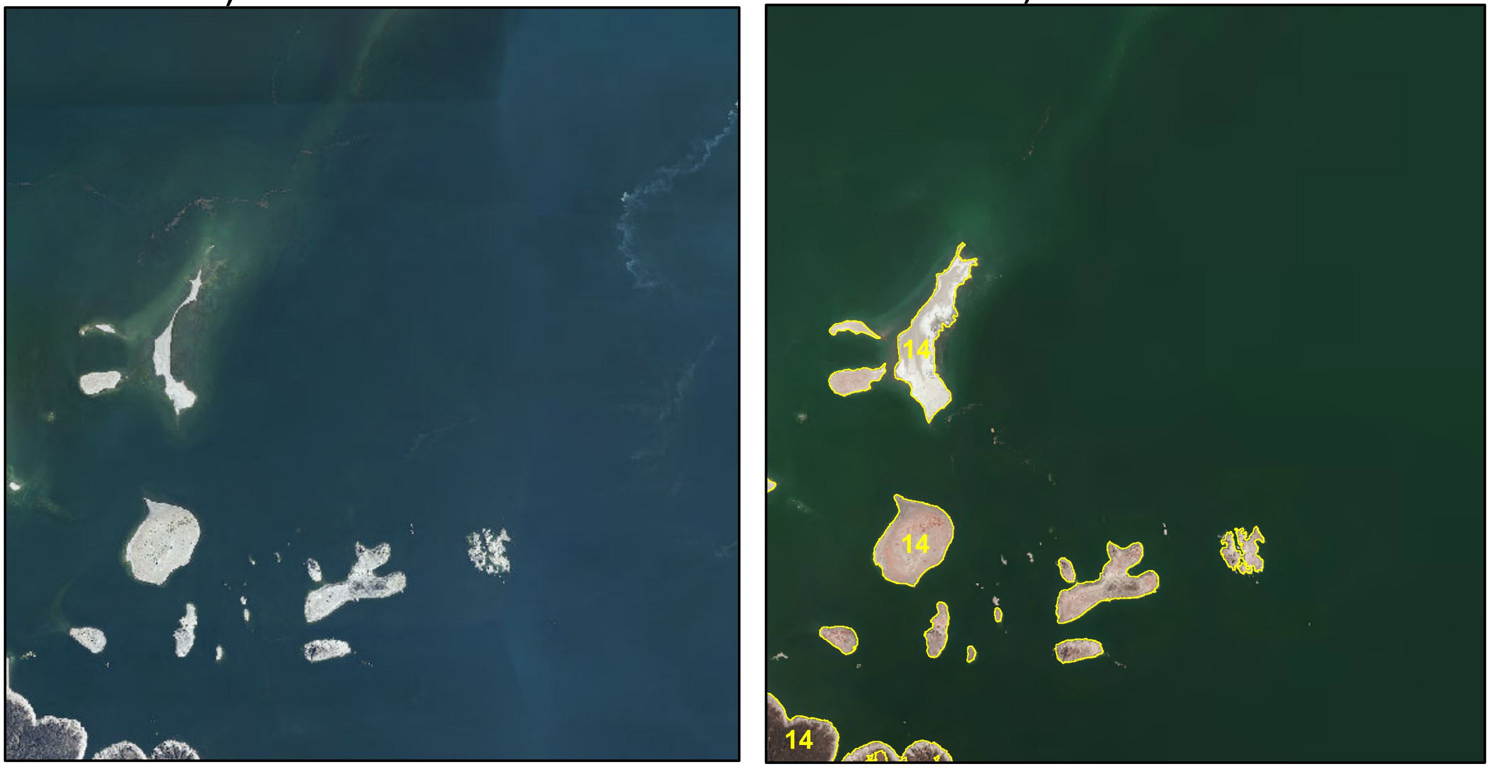


Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.



A) 1999 conditions.

B) 2005 conditions.



C) 2009 conditions.

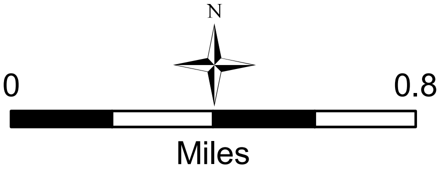
D) 2014 conditions.

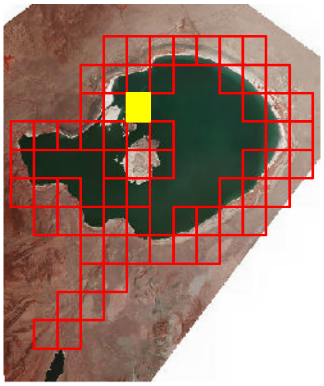
Mono Lake Landtype, Historical Conditions

Landtype Legend

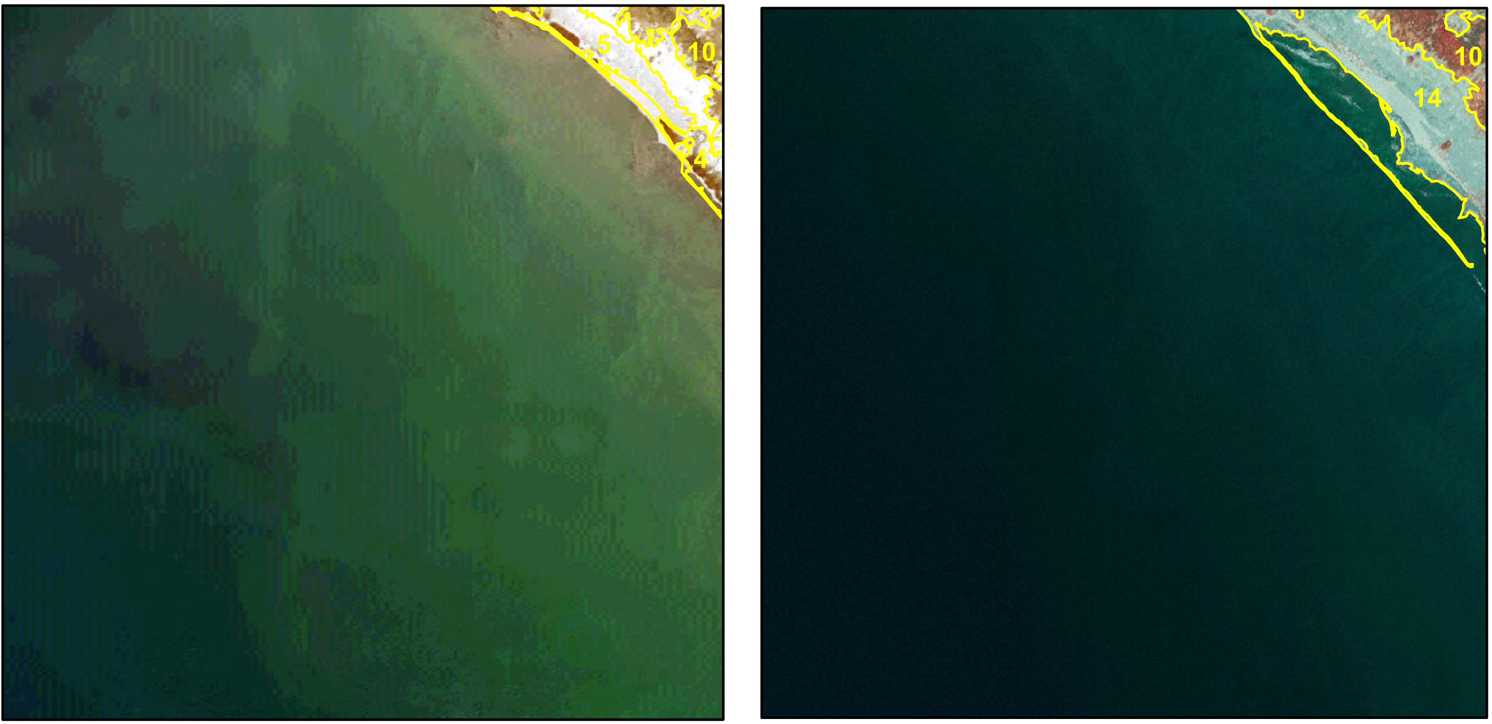
1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map C6



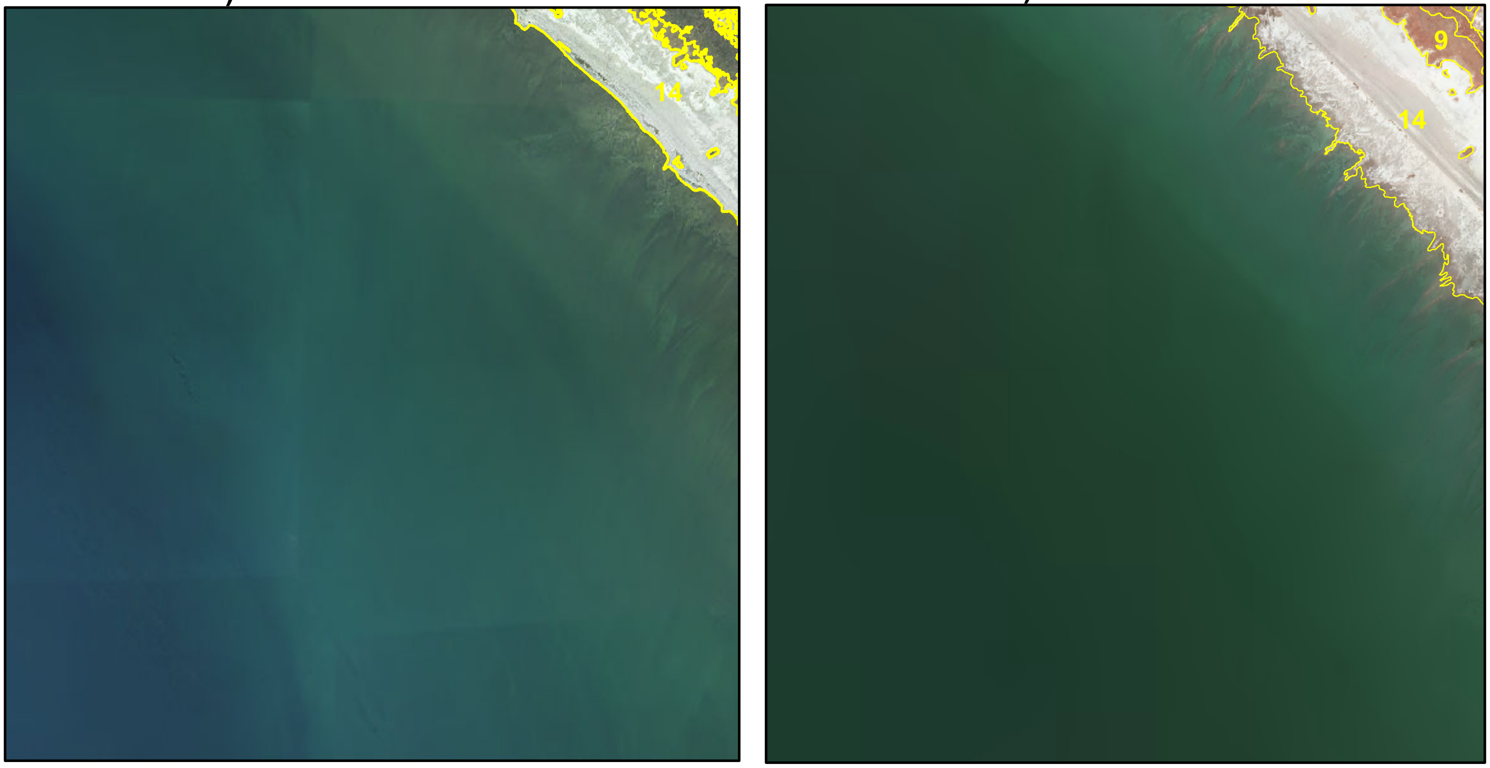


Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.



A) 1999 conditions.

B) 2005 conditions.



C) 2009 conditions.

D) 2014 conditions.

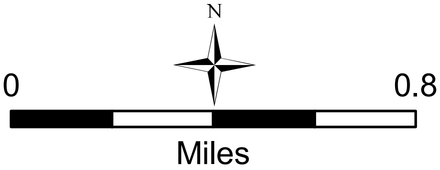
Mono Lake Landtype, Historical Conditions

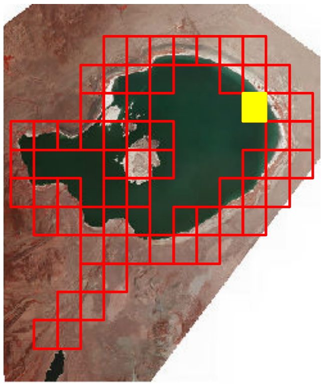
Landtype Legend

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow

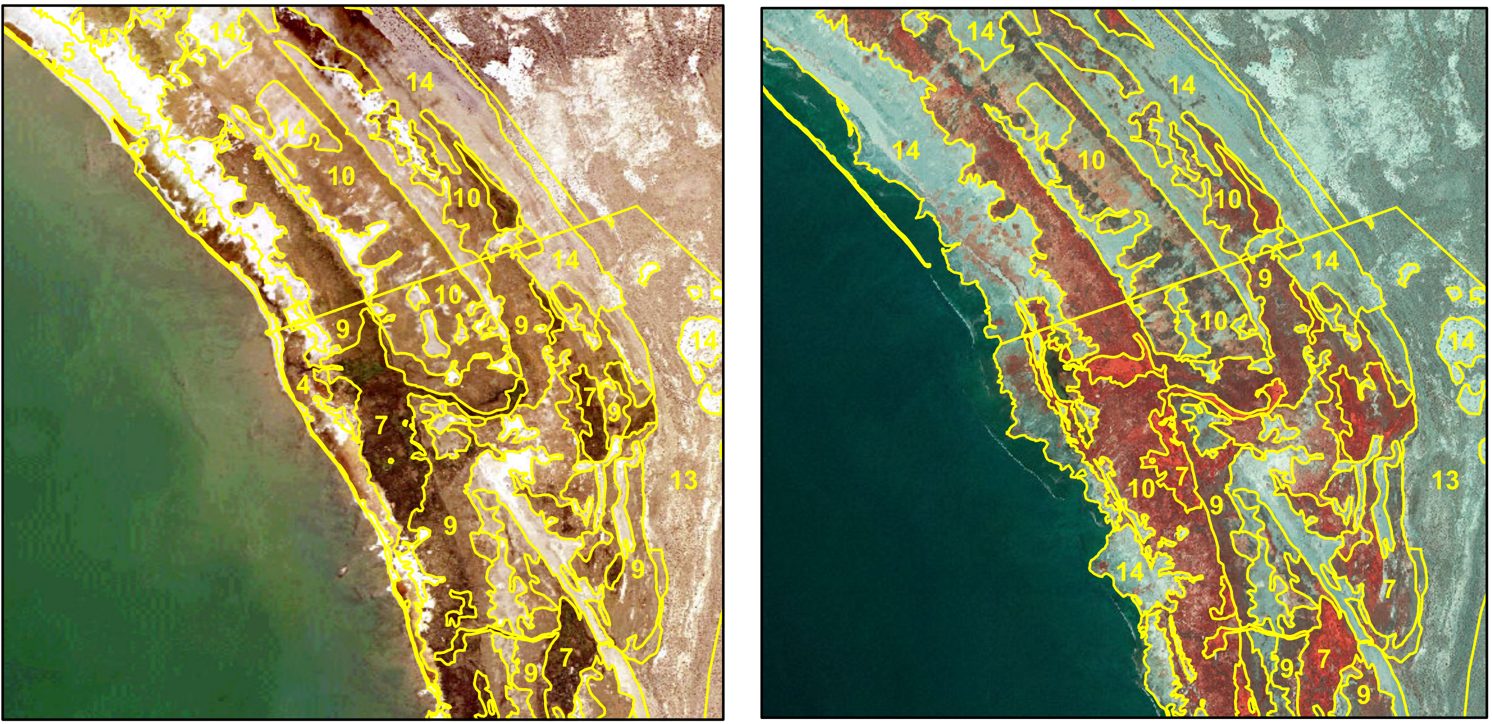
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map C11



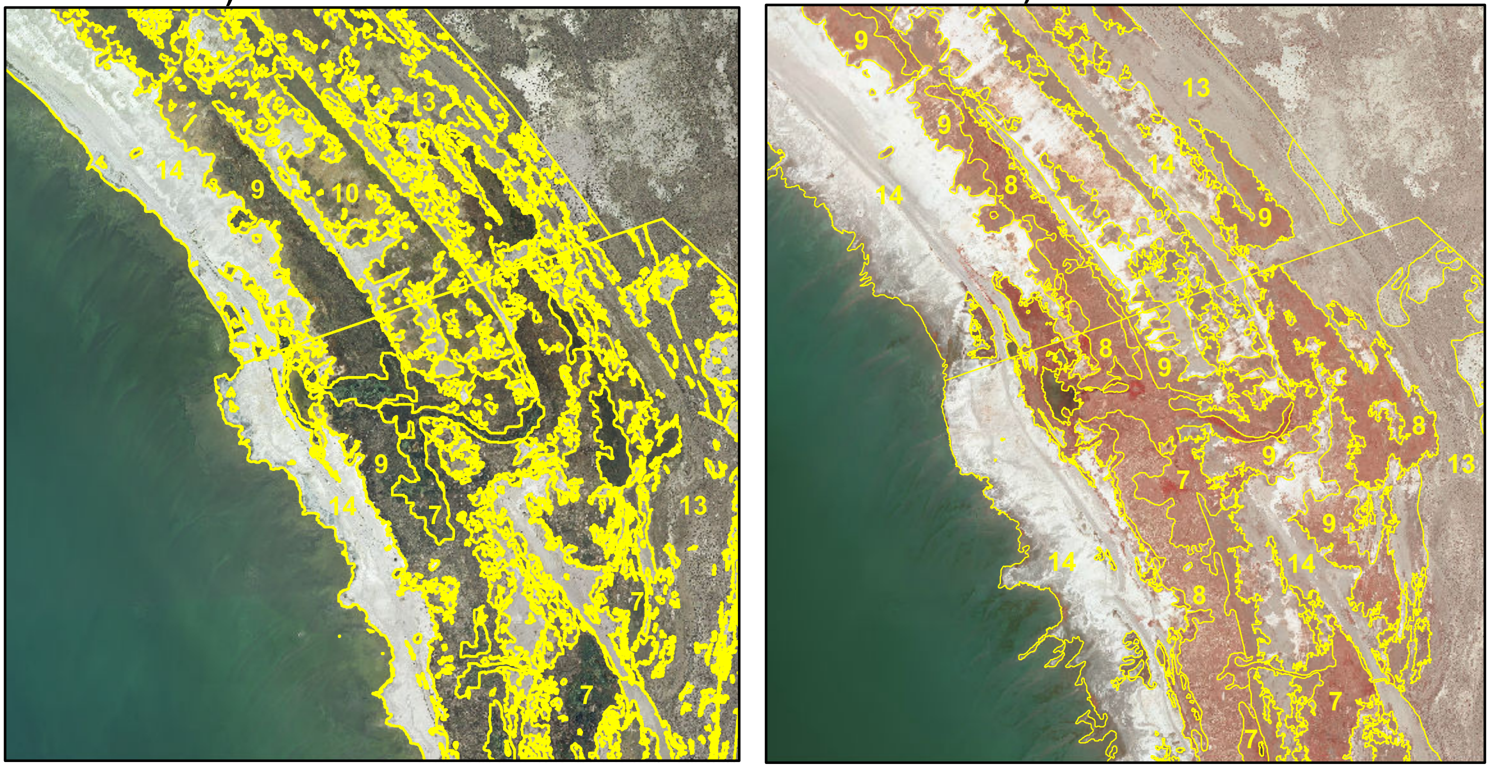


Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.



A) 1999 conditions.

B) 2005 conditions.



C) 2009 conditions.

D) 2014 conditions.

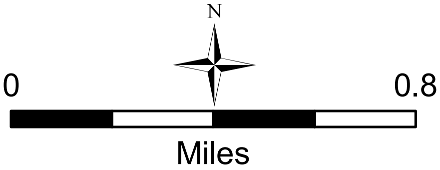
Mono Lake Landtype, Historical Conditions

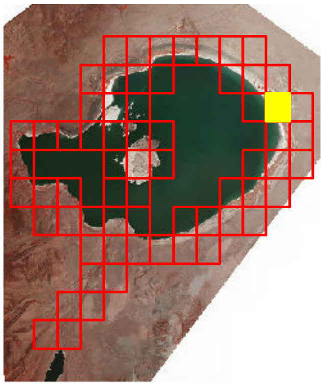
Landtype Legend

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow

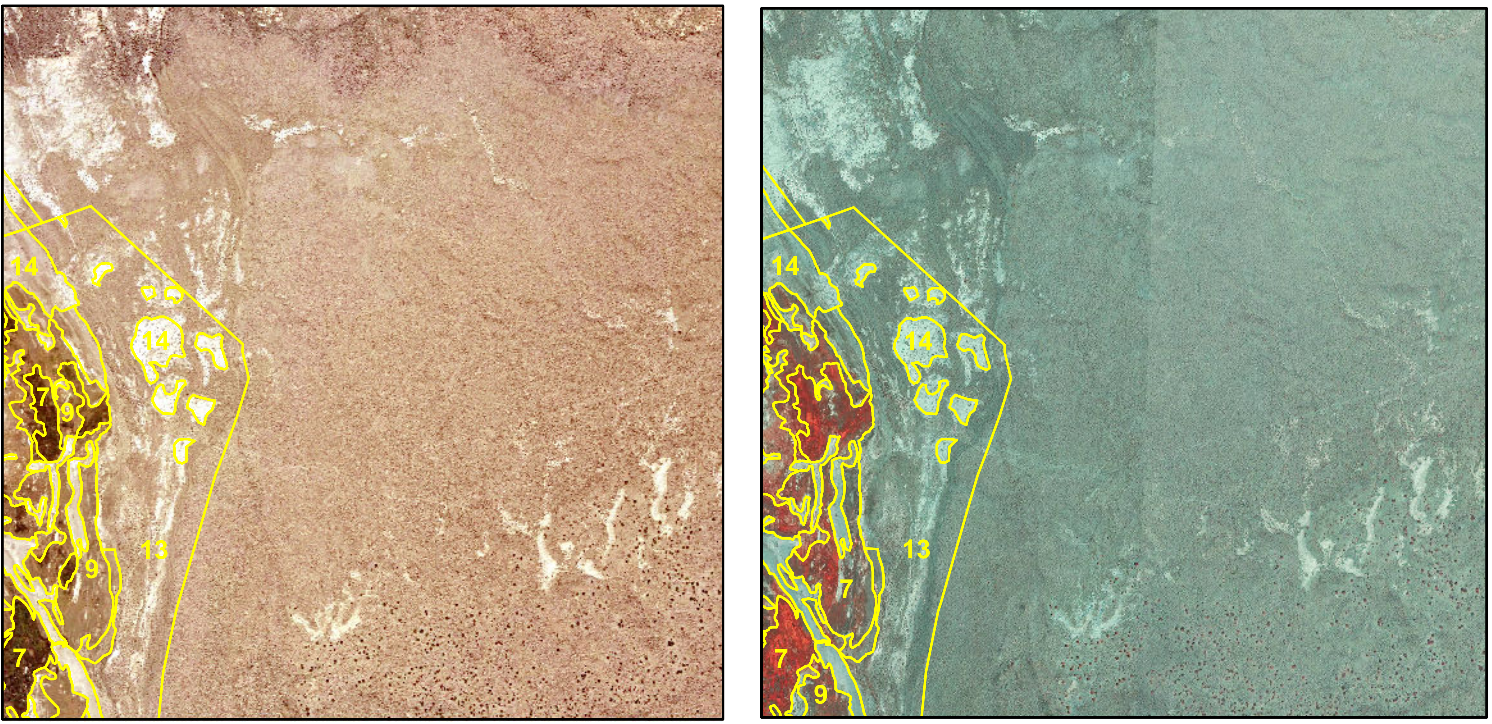
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map C12



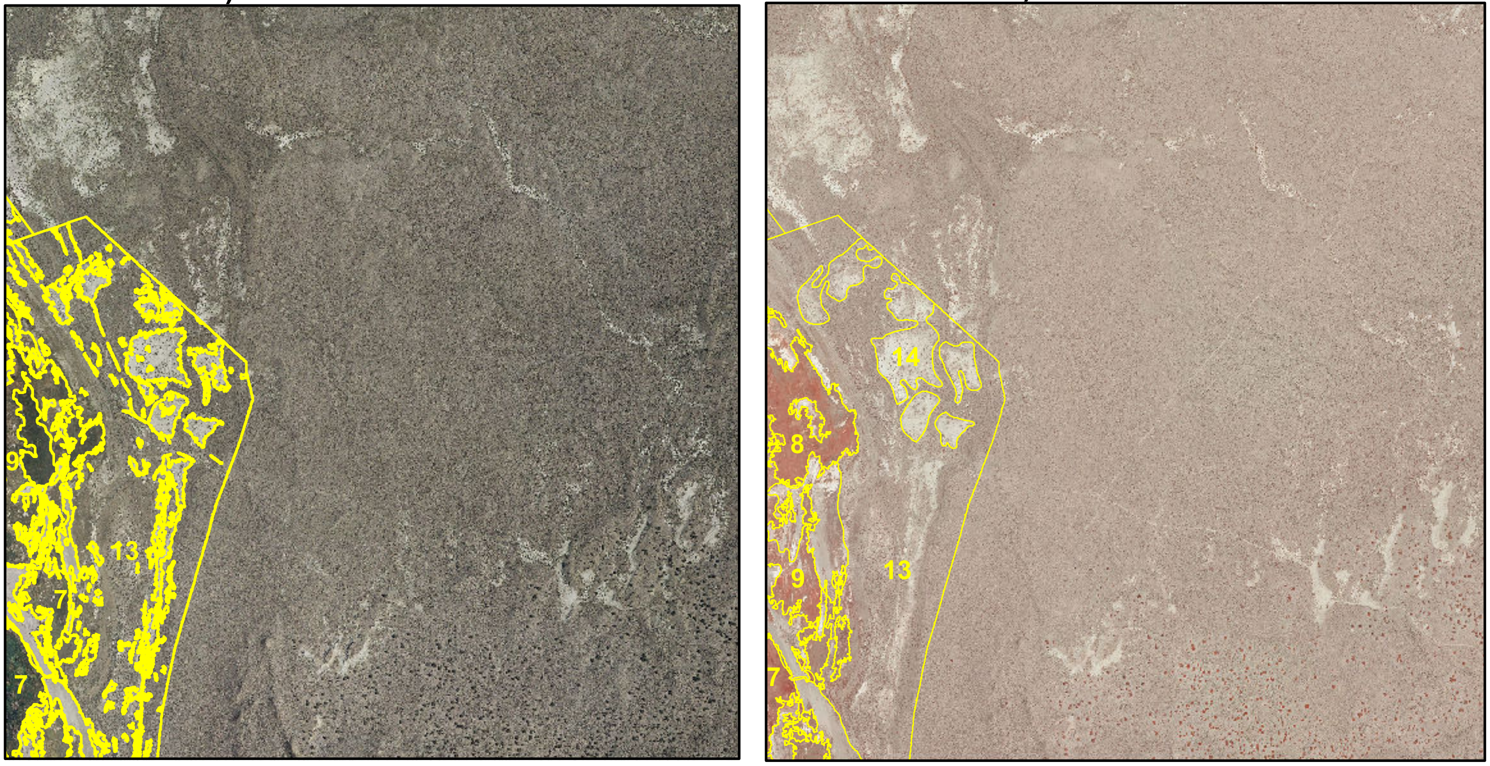


Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.



A) 1999 conditions.

B) 2005 conditions.



C) 2009 conditions.

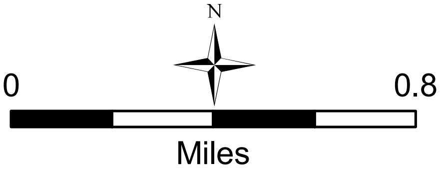
D) 2014 conditions.

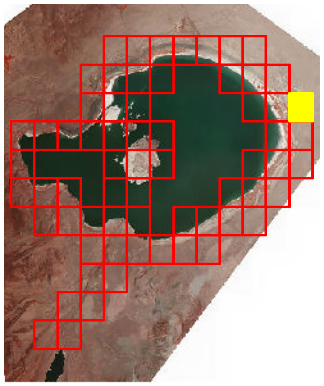
Mono Lake Landtype, Historical Conditions

Landtype Legend

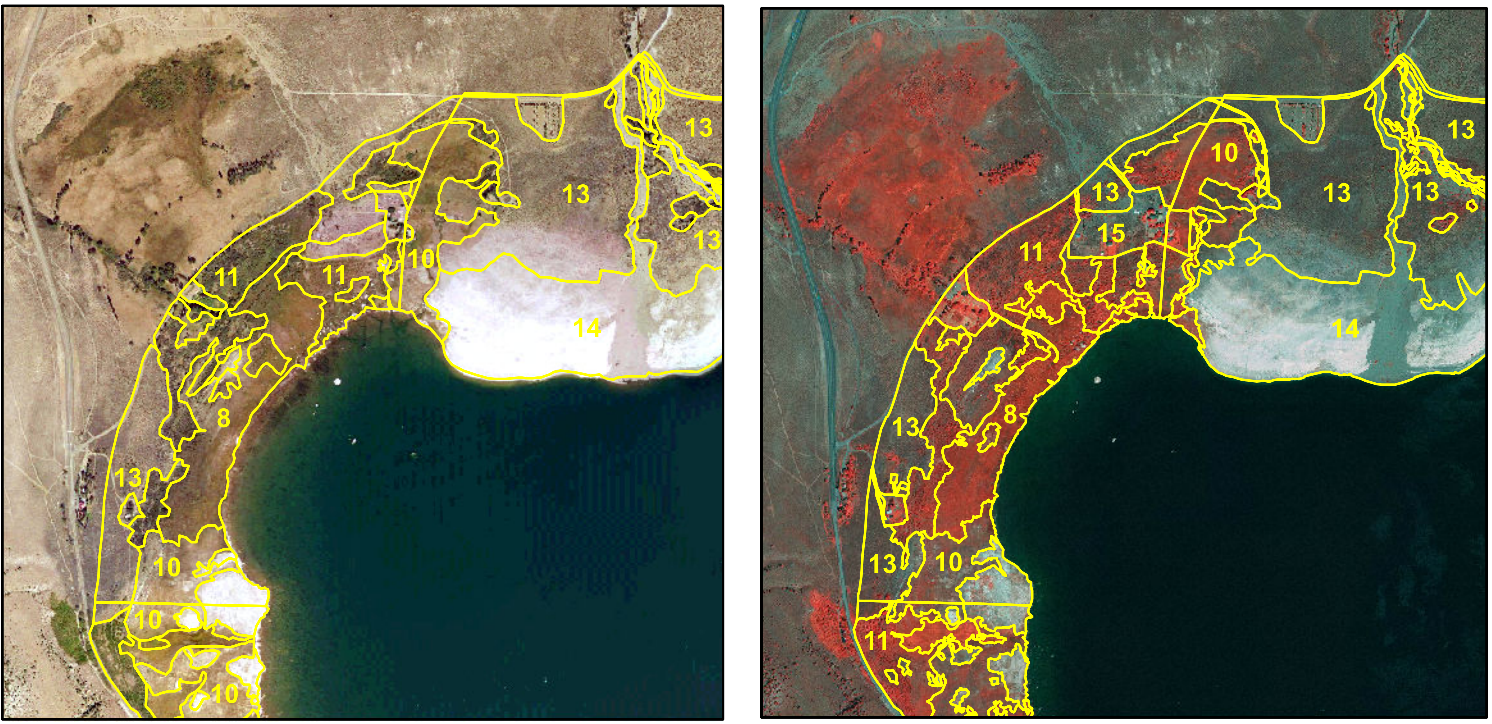
1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map C13



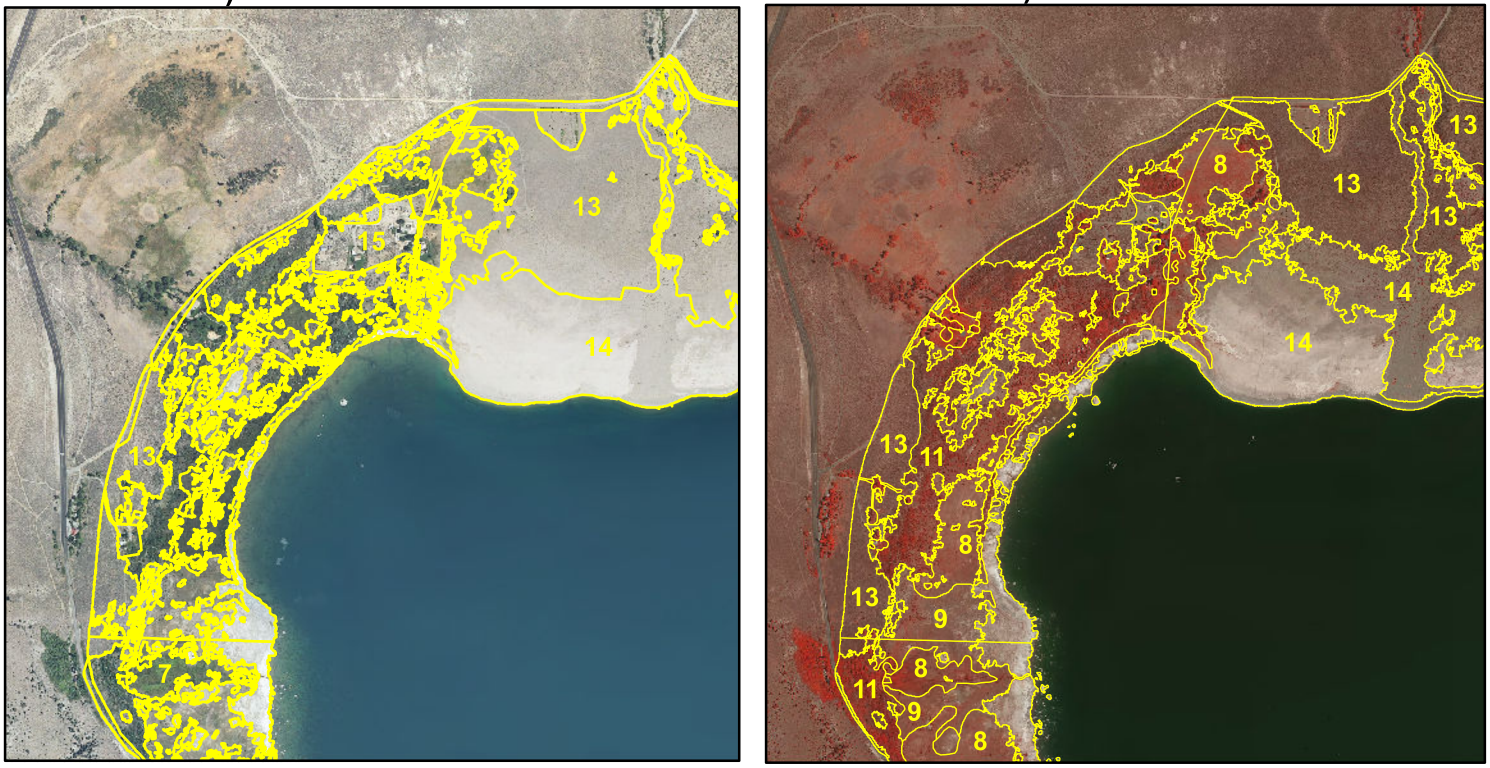


Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.



A) 1999 conditions.

B) 2005 conditions.



C) 2009 conditions.

D) 2014 conditions.

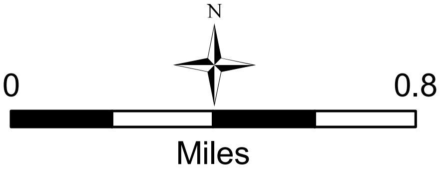
Mono Lake Landtype, Historical Conditions

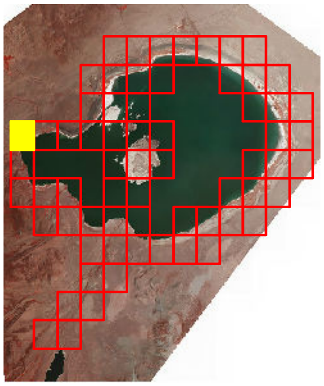
Landtype Legend

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow

9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map D1

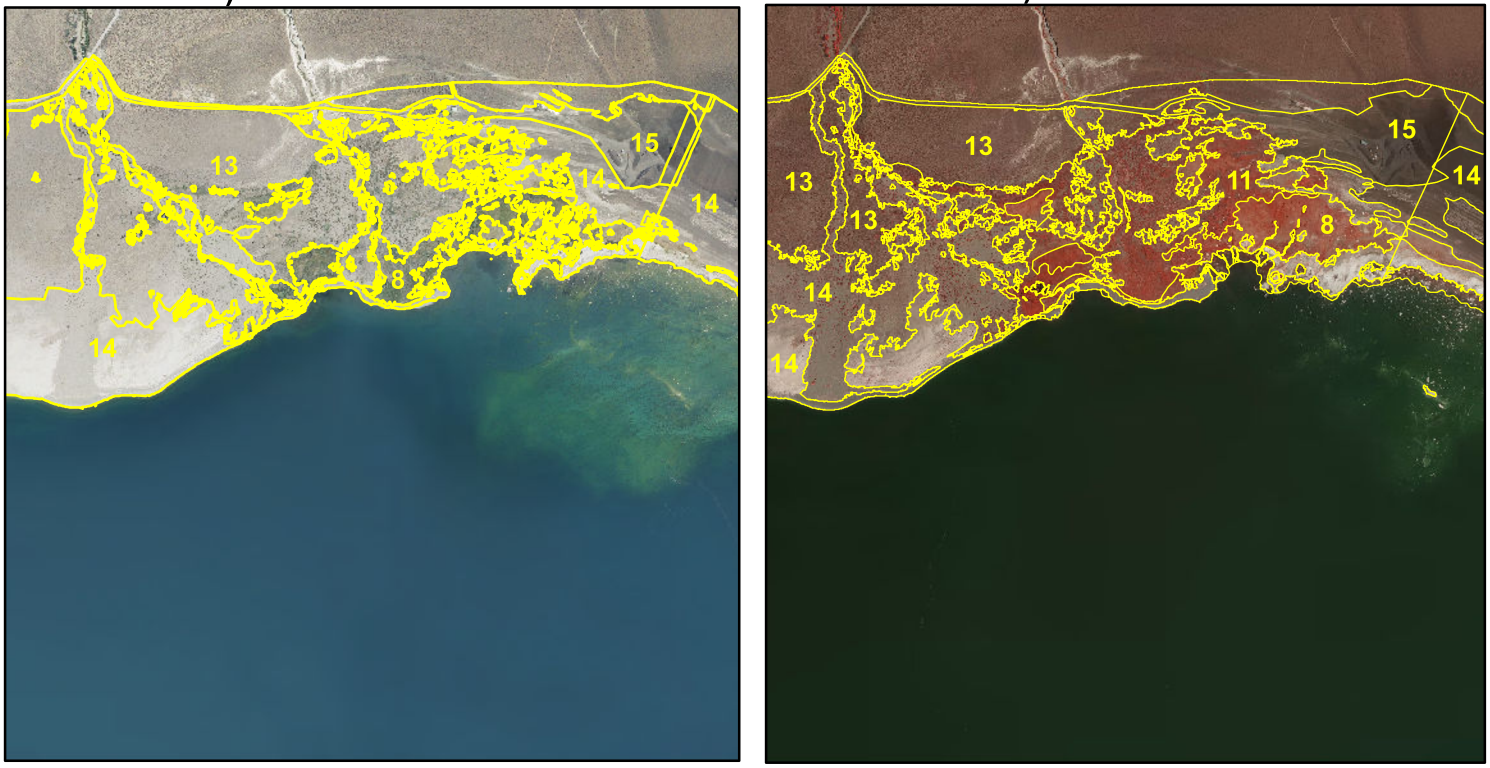




Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.

A) 1999 conditions.

B) 2005 conditions.



C) 2009 conditions.

D) 2014 conditions.

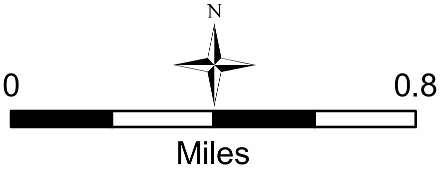
Mono Lake Landtype, Historical Conditions

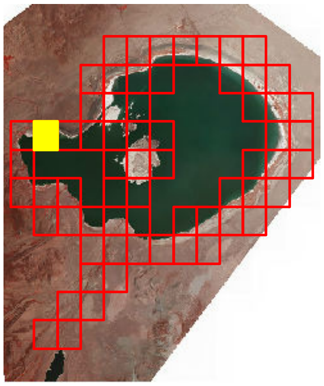
Landtype Legend

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow

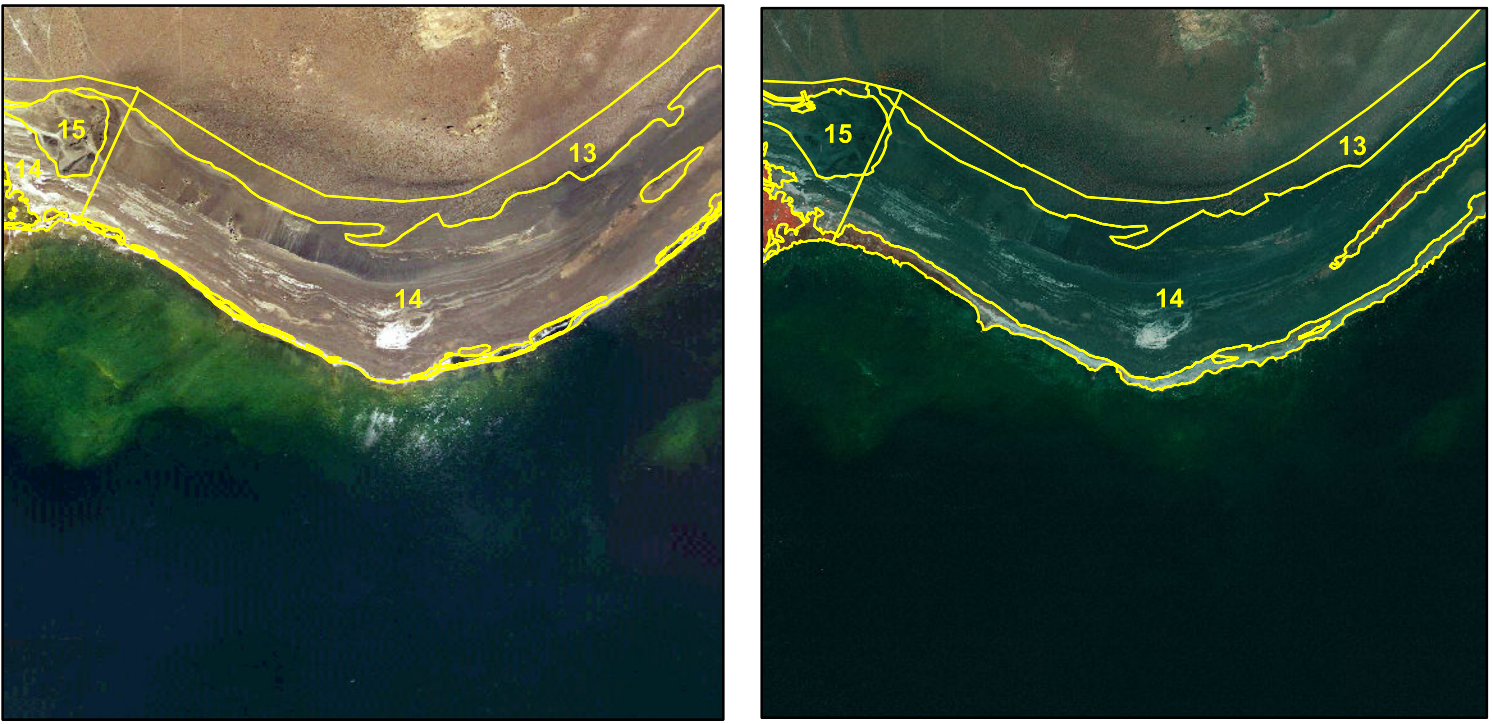
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map D2



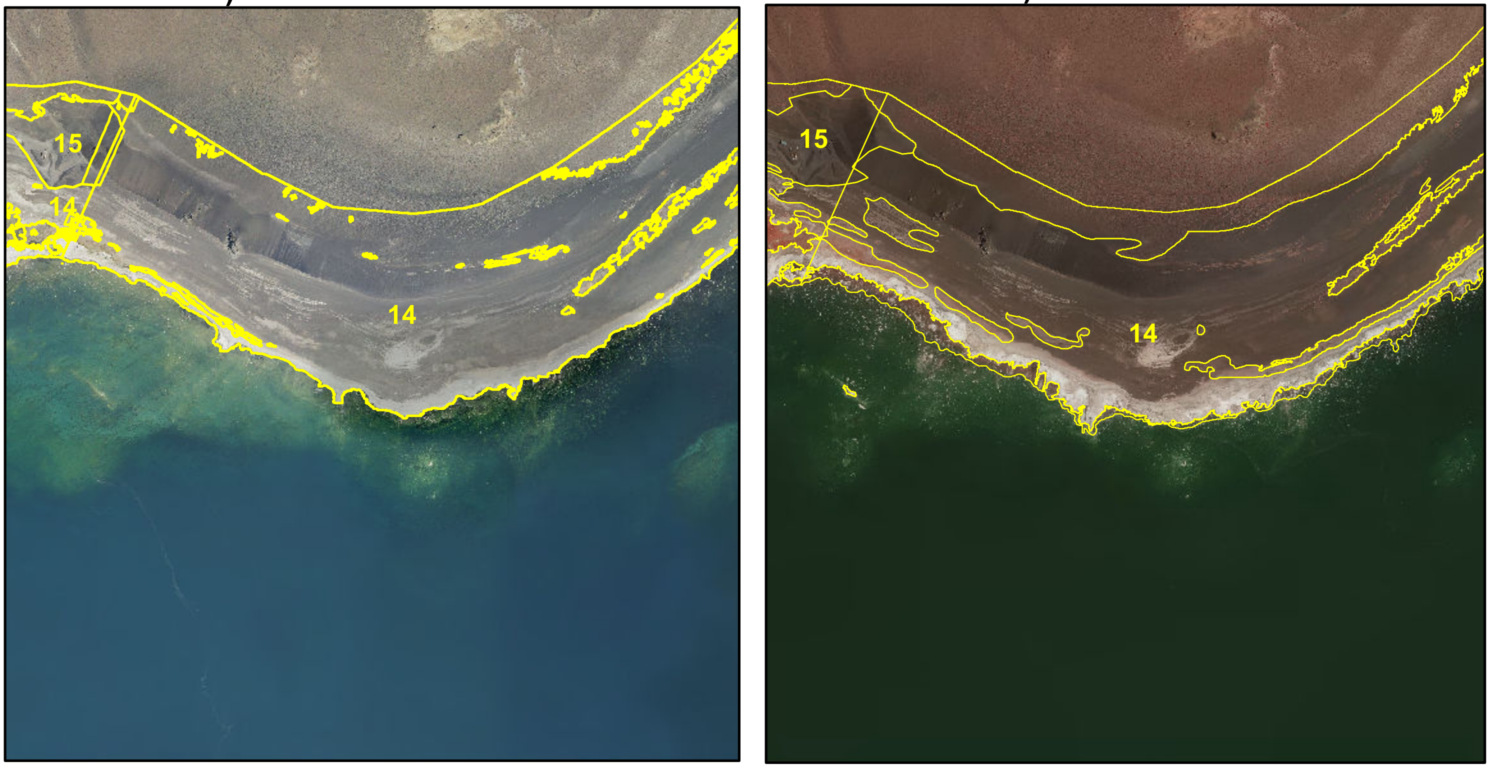


Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.



A) 1999 conditions.

B) 2005 conditions.



C) 2009 conditions.

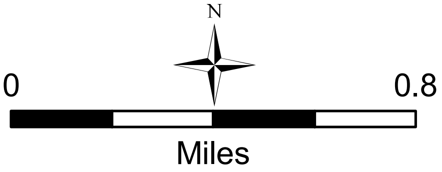
D) 2014 conditions.

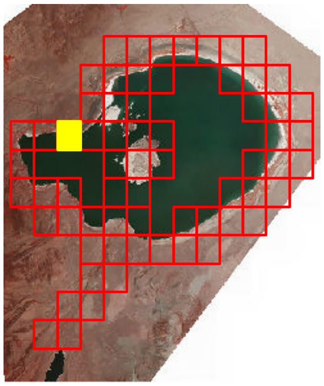
Mono Lake Landtype, Historical Conditions

Landtype Legend

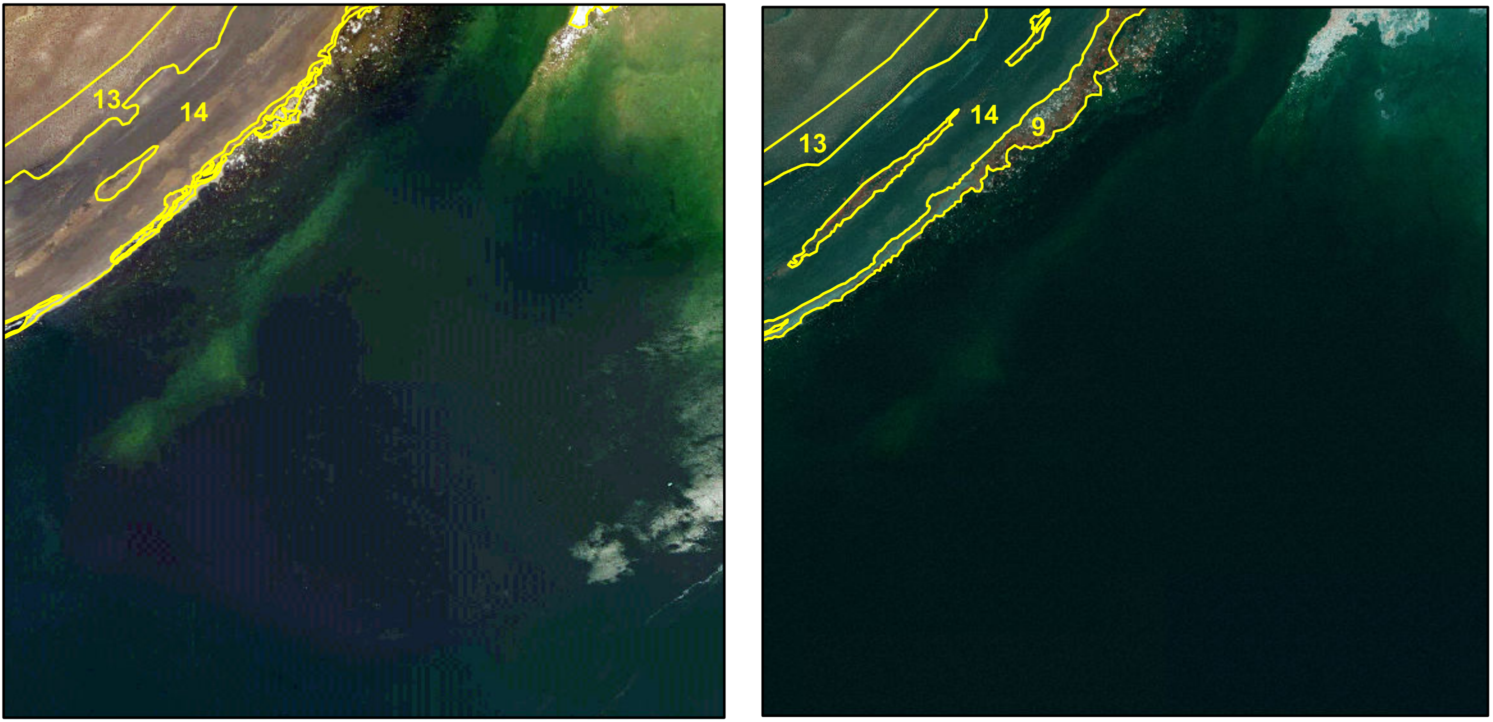
1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map D3



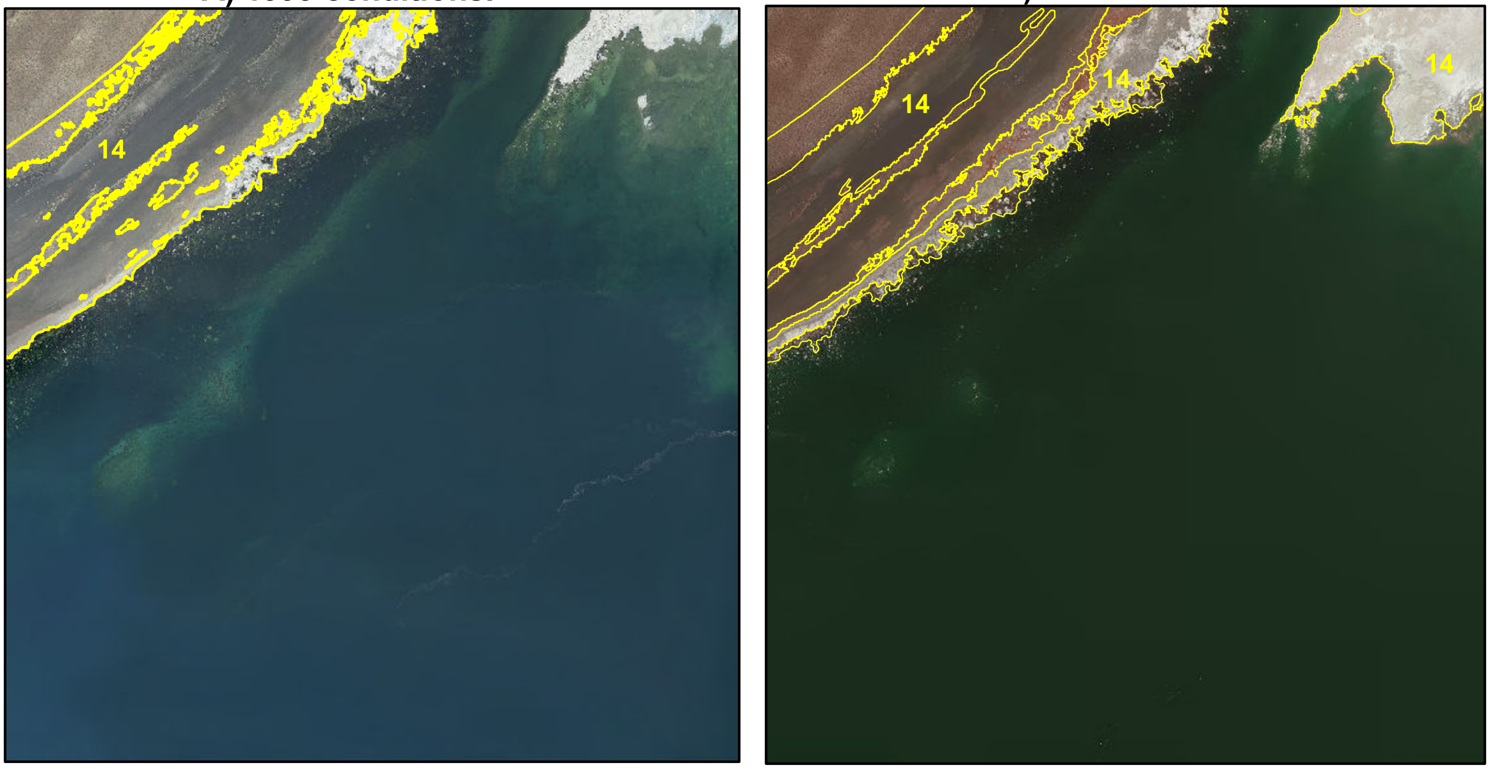


Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.



A) 1999 conditions.

B) 2005 conditions.



C) 2009 conditions.

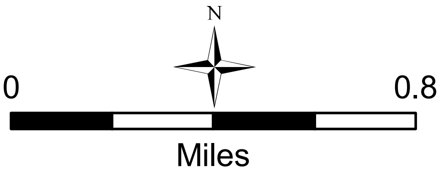
D) 2014 conditions.

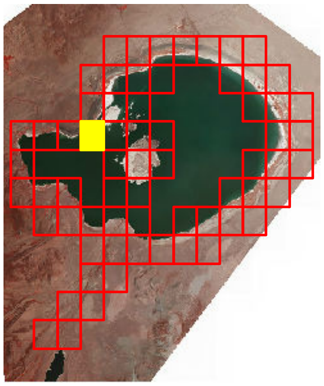
Mono Lake Landtype, Historical Conditions

Landtype Legend

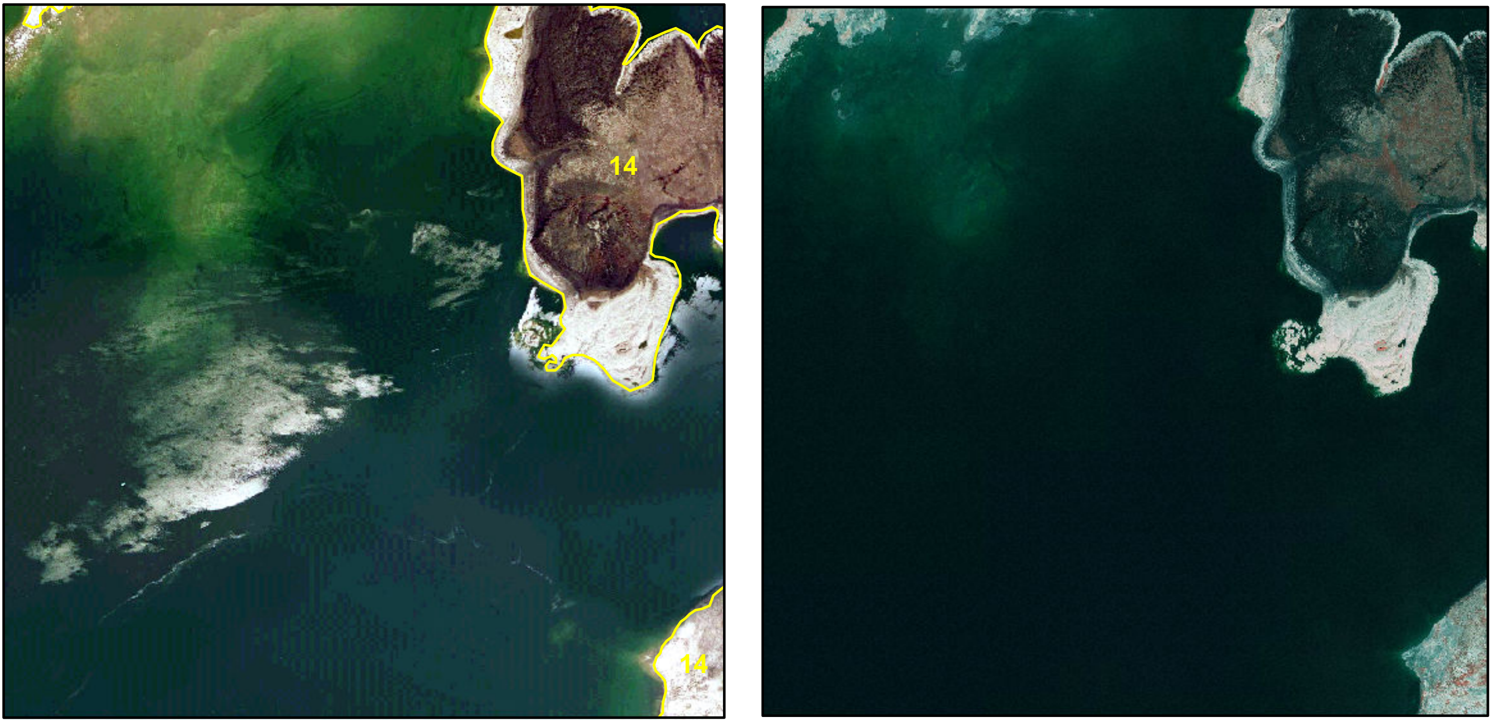
1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map D4



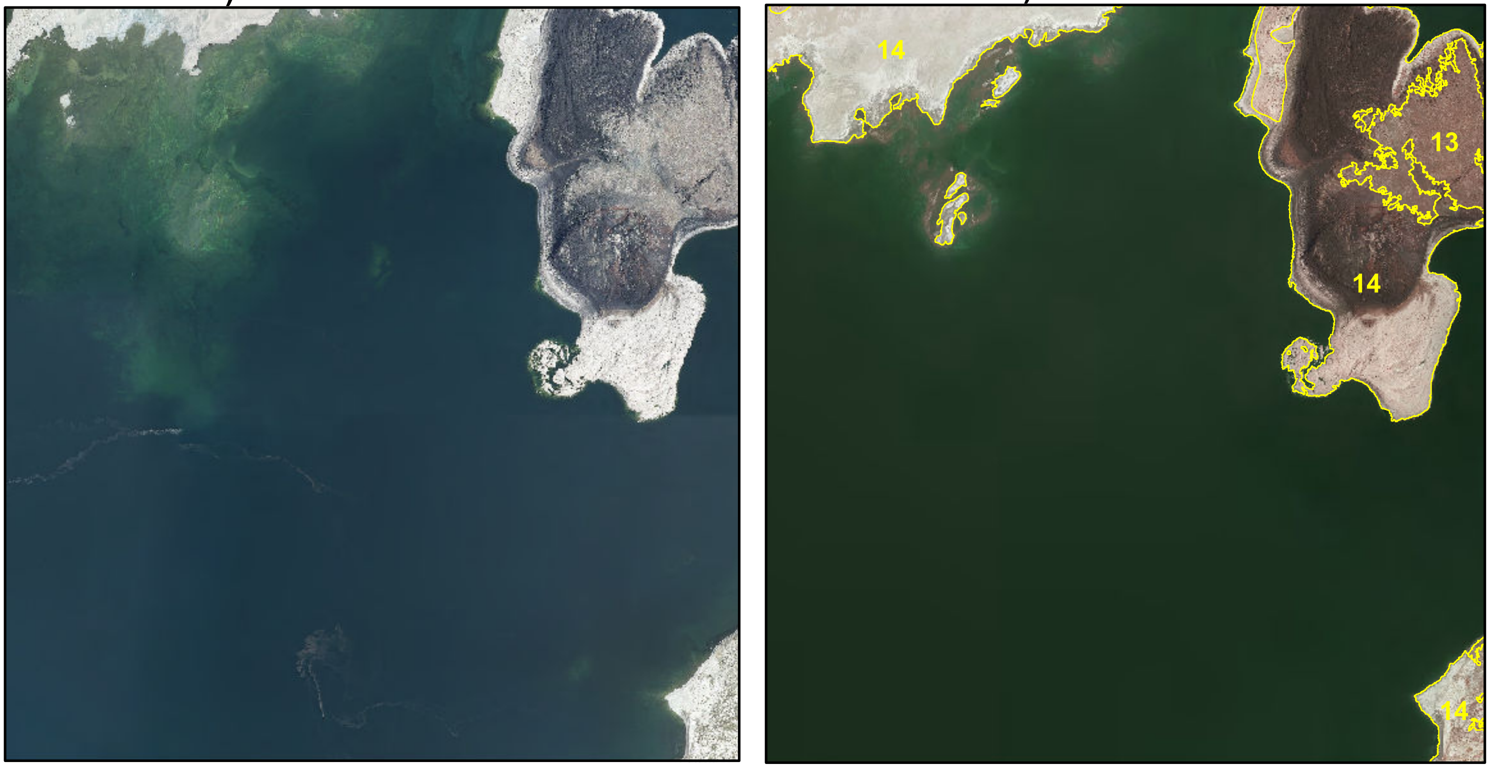


Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.



A) 1999 conditions.

B) 2005 conditions.



C) 2009 conditions.

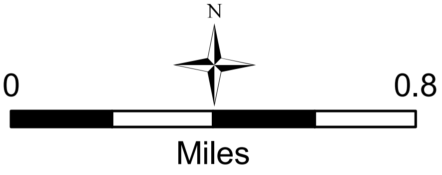
D) 2014 conditions.

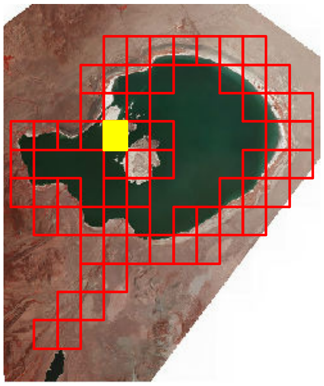
Mono Lake Landtype, Historical Conditions

Landtype Legend

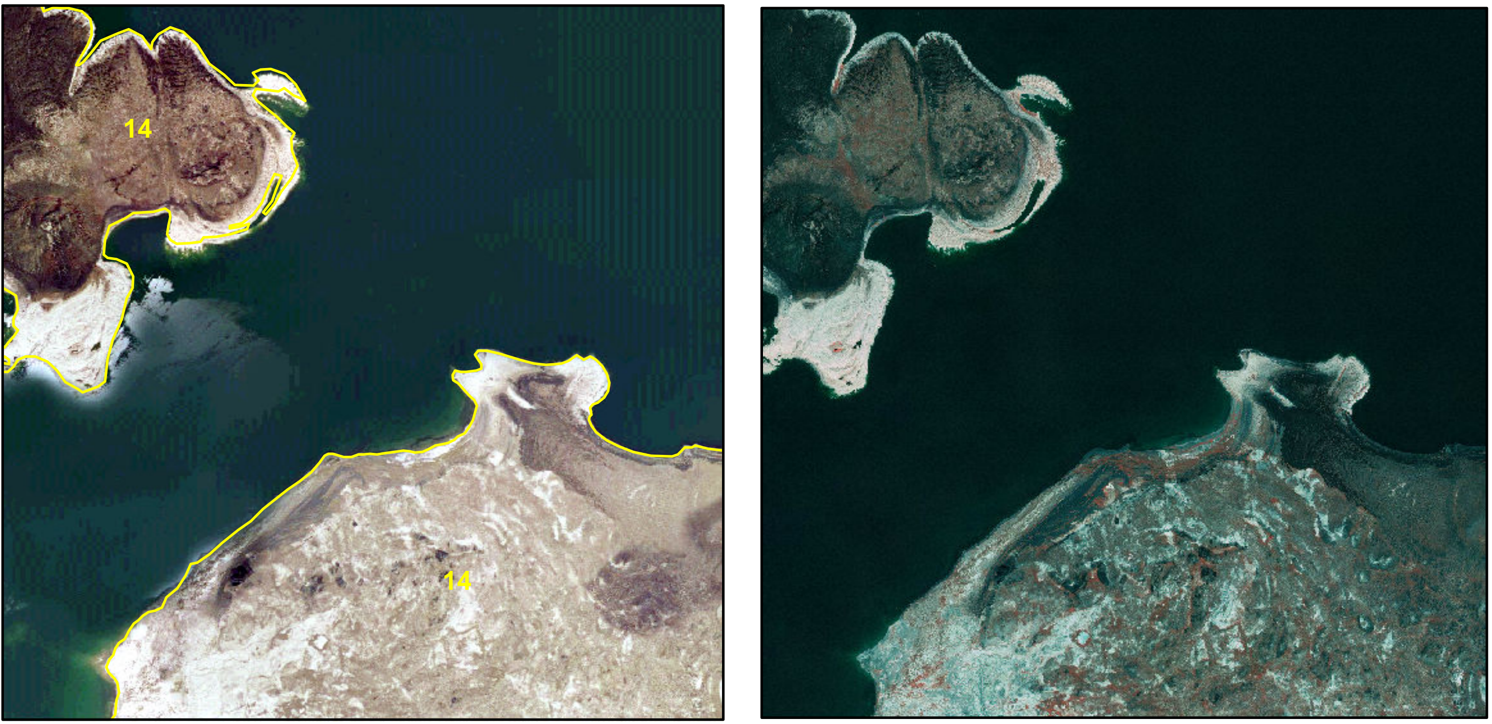
1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map D5





Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.



A) 1999 conditions.

B) 2005 conditions.

C) 2009 conditions.

D) 2014 conditions.

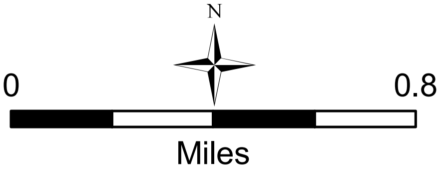
Mono Lake Landtype, Historical Conditions

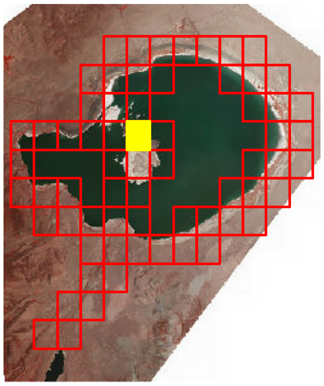
Landtype Legend

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow

9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

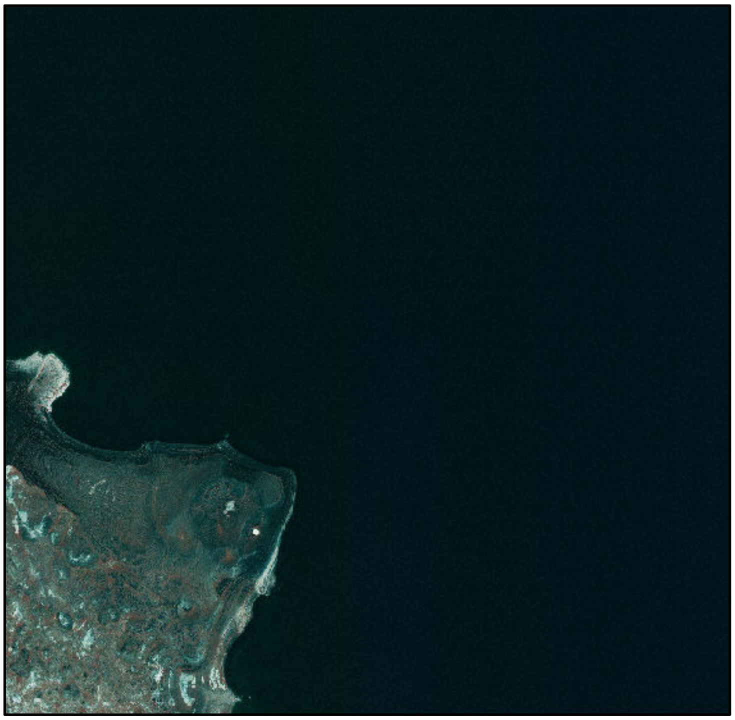
Map D6



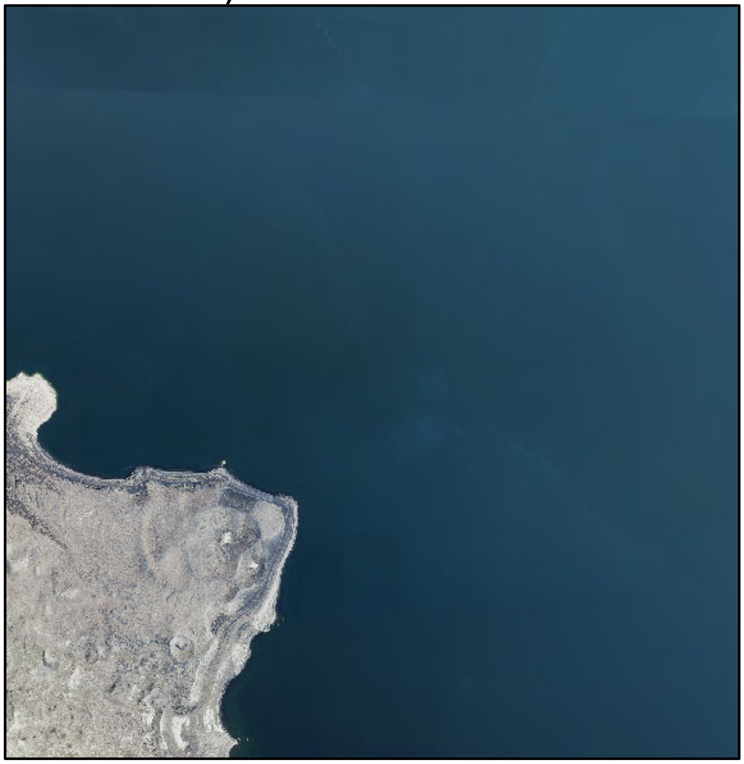


Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.

A) 1999 conditions.



B) 2005 conditions.



C) 2009 conditions.

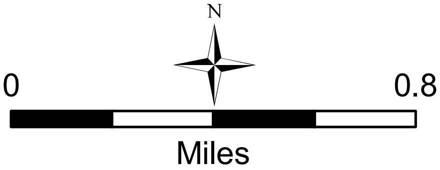
D) 2014 conditions.

Mono Lake Landtype, Historical Conditions

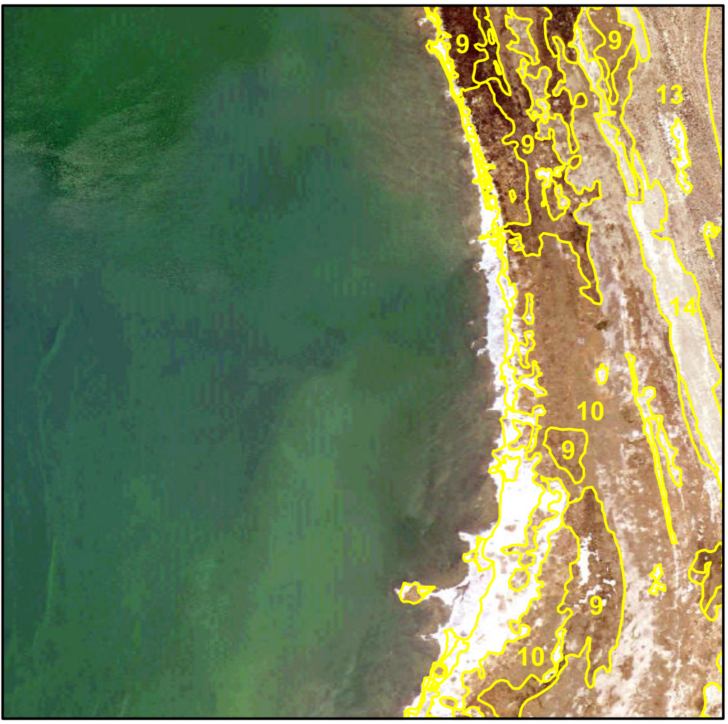
Landtype Legend

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

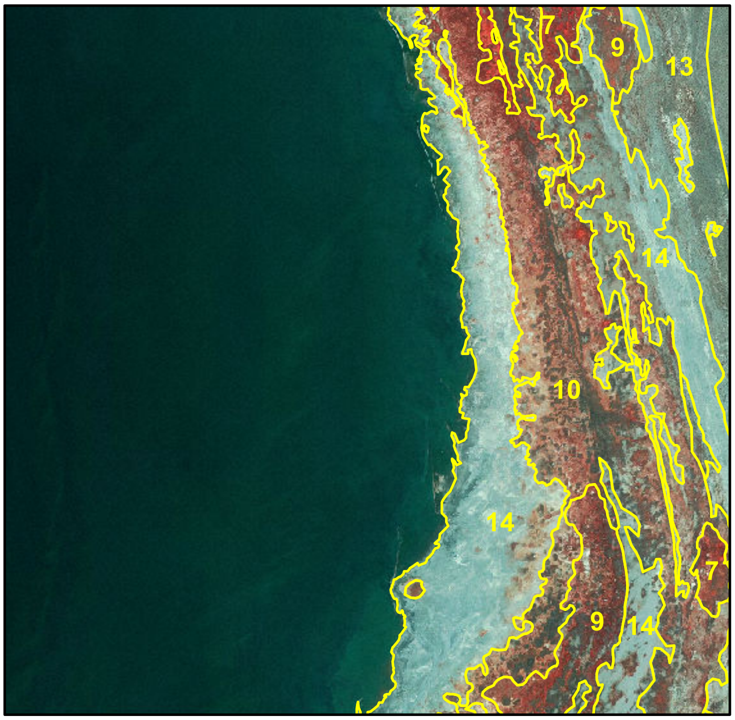
Map D7



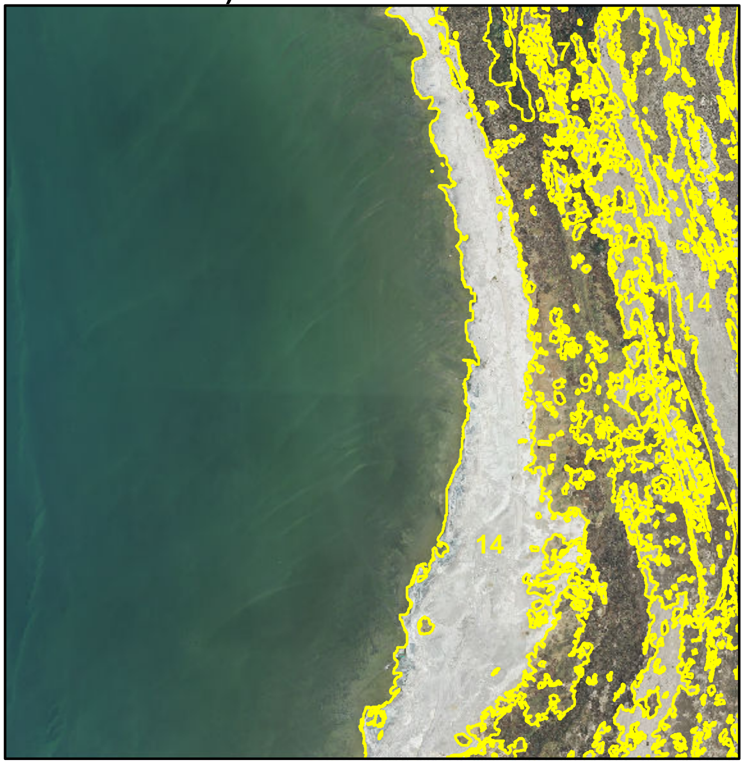
Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.



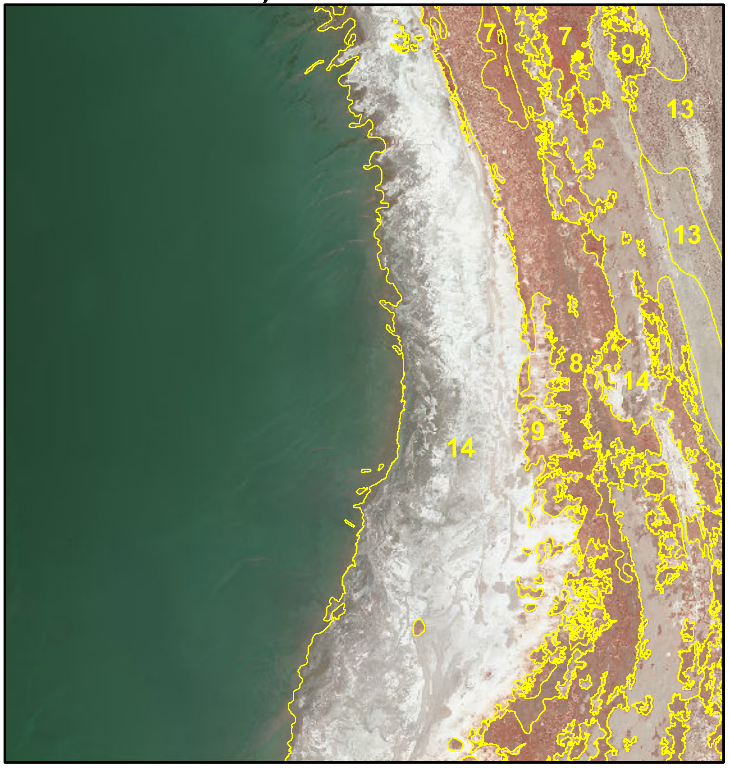
A) 1999 conditions.



B) 2005 conditions.



C) 2009 conditions.



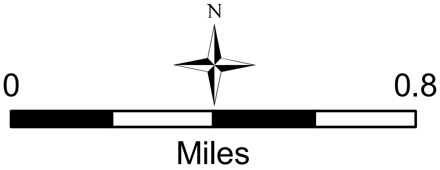
D) 2014 conditions.

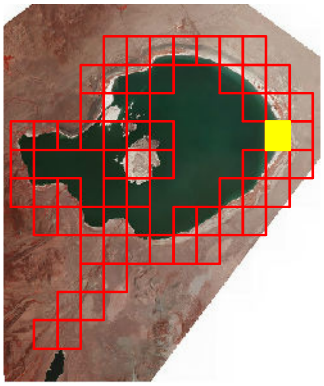
Mono Lake Landtype, Historical Conditions

Landtype Legend

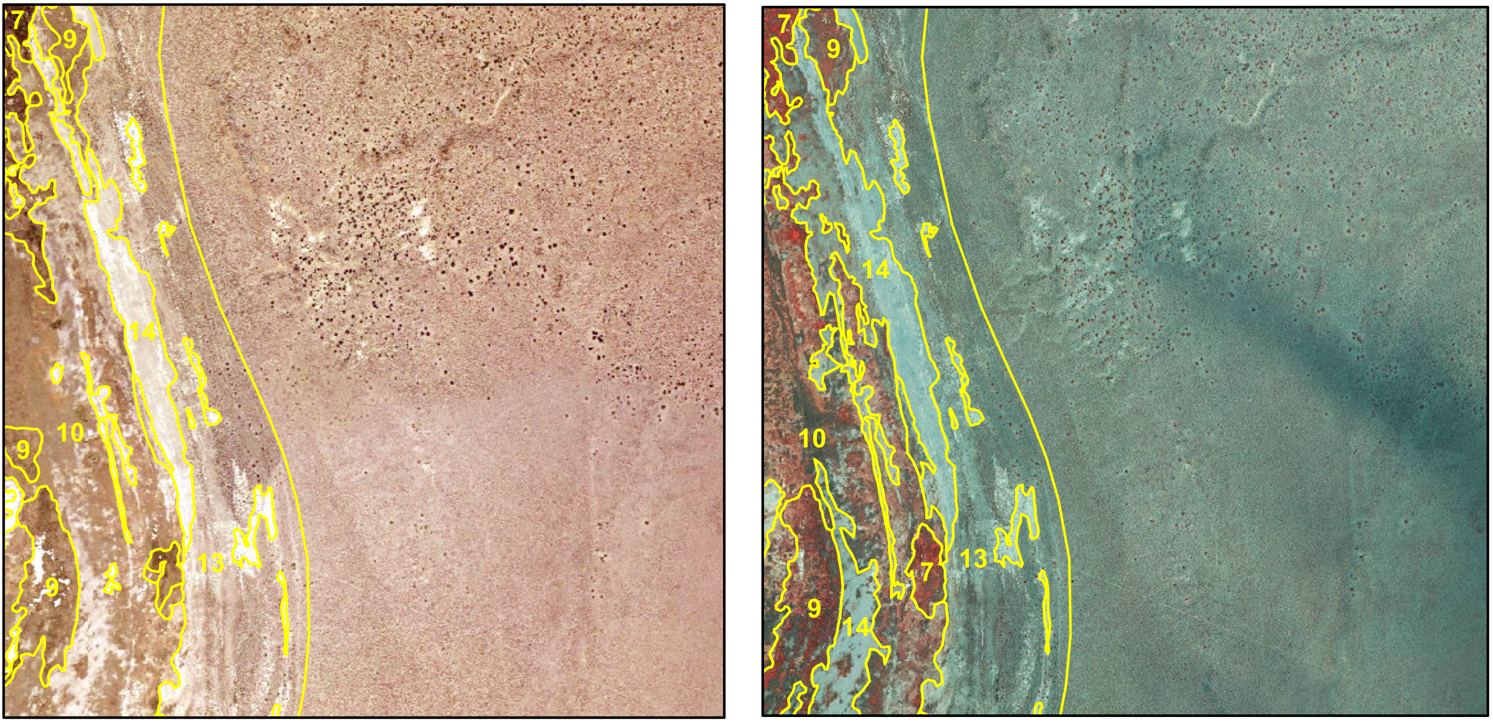
1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map D12



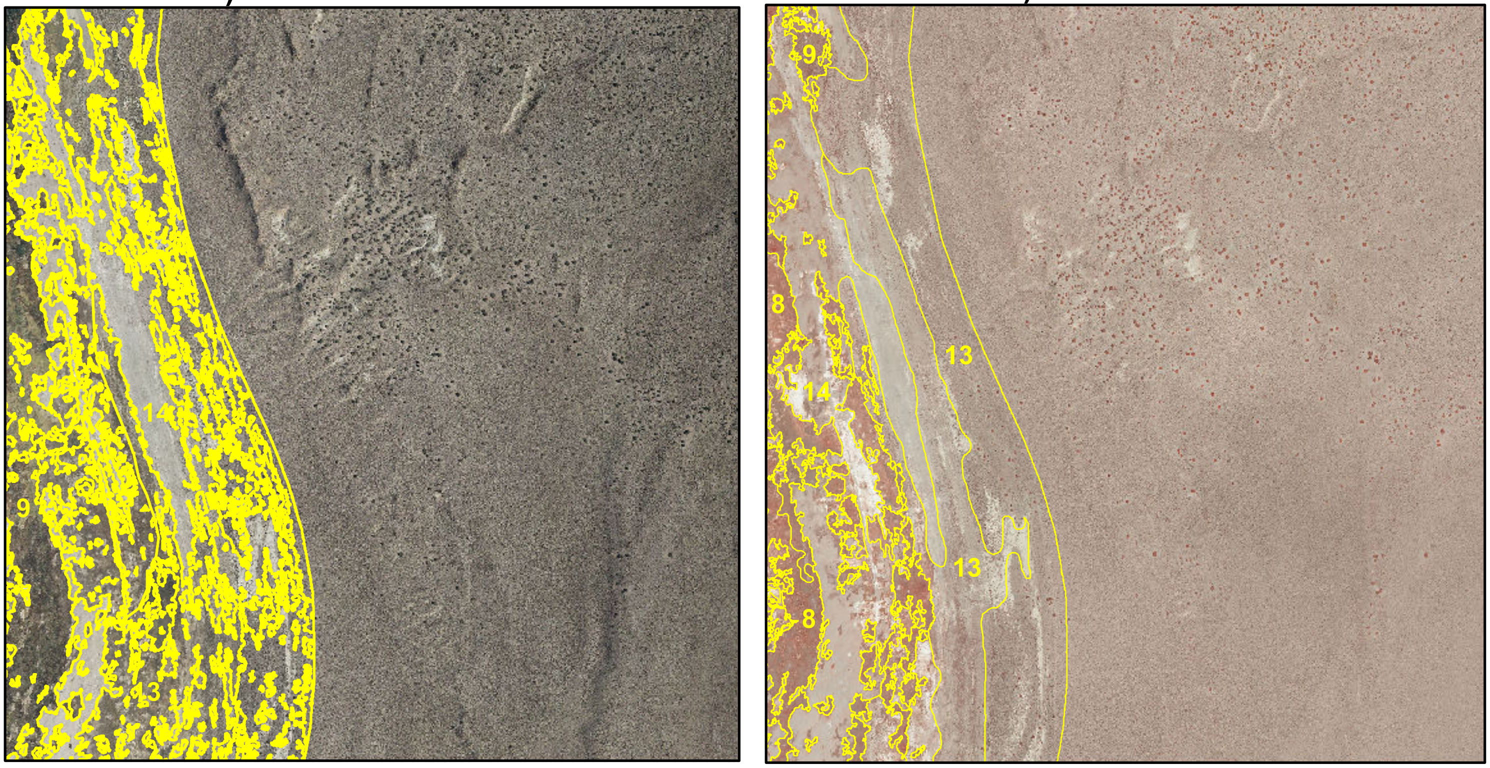


Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.



A) 1999 conditions.

B) 2005 conditions.



C) 2009 conditions.

D) 2014 conditions.

Mono Lake Landtype, Historical Conditions

Landtype Legend

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow

9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
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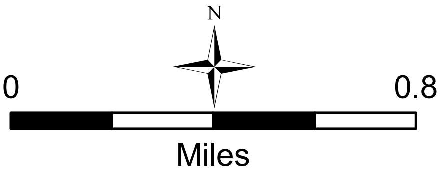
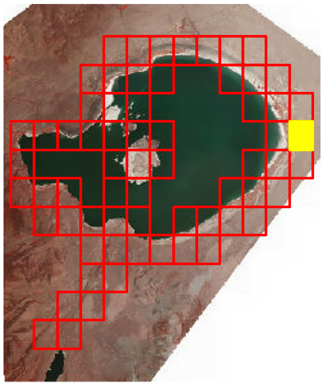
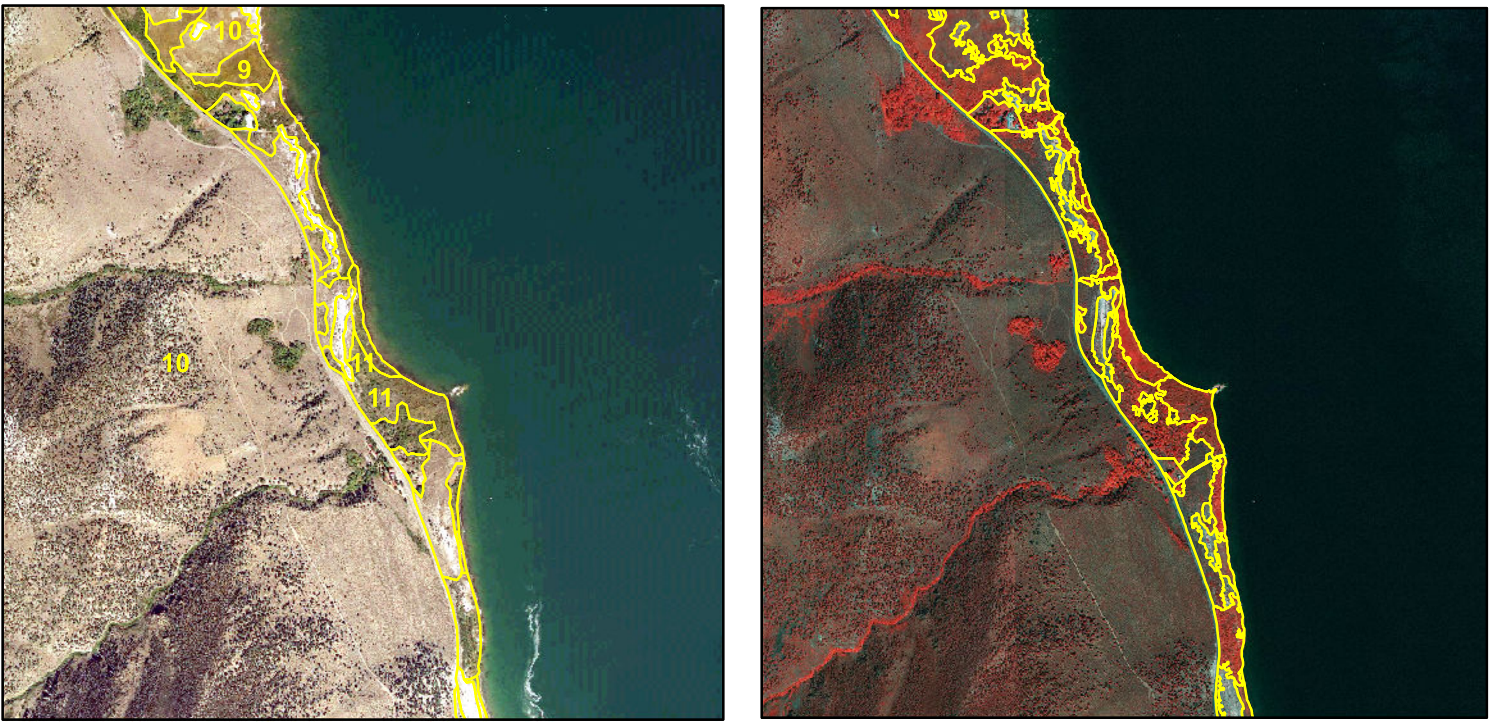
Map D13



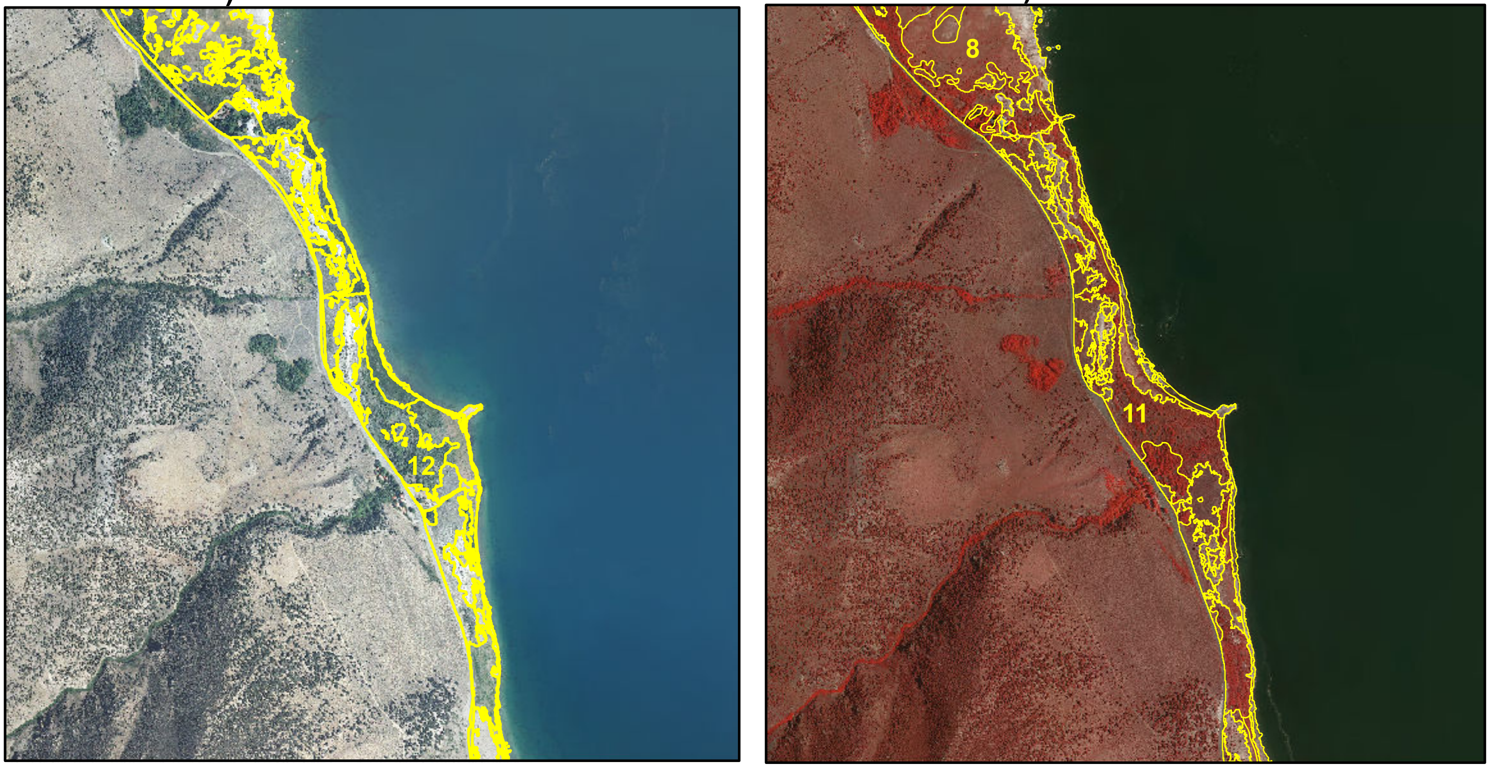


Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.



A) 1999 conditions.

B) 2005 conditions.



C) 2009 conditions.

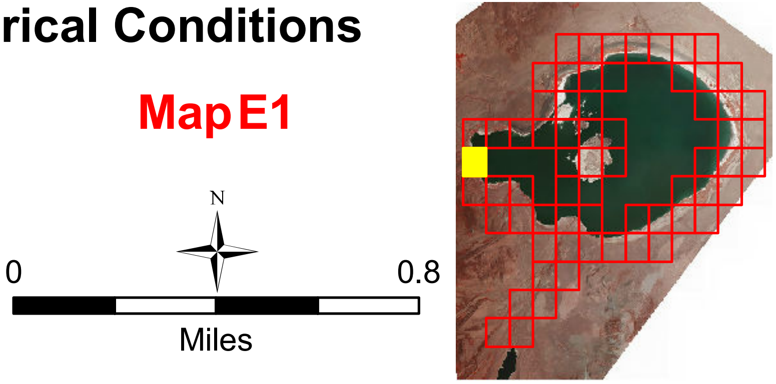
D) 2014 conditions.

Mono Lake Landtype, Historical Conditions

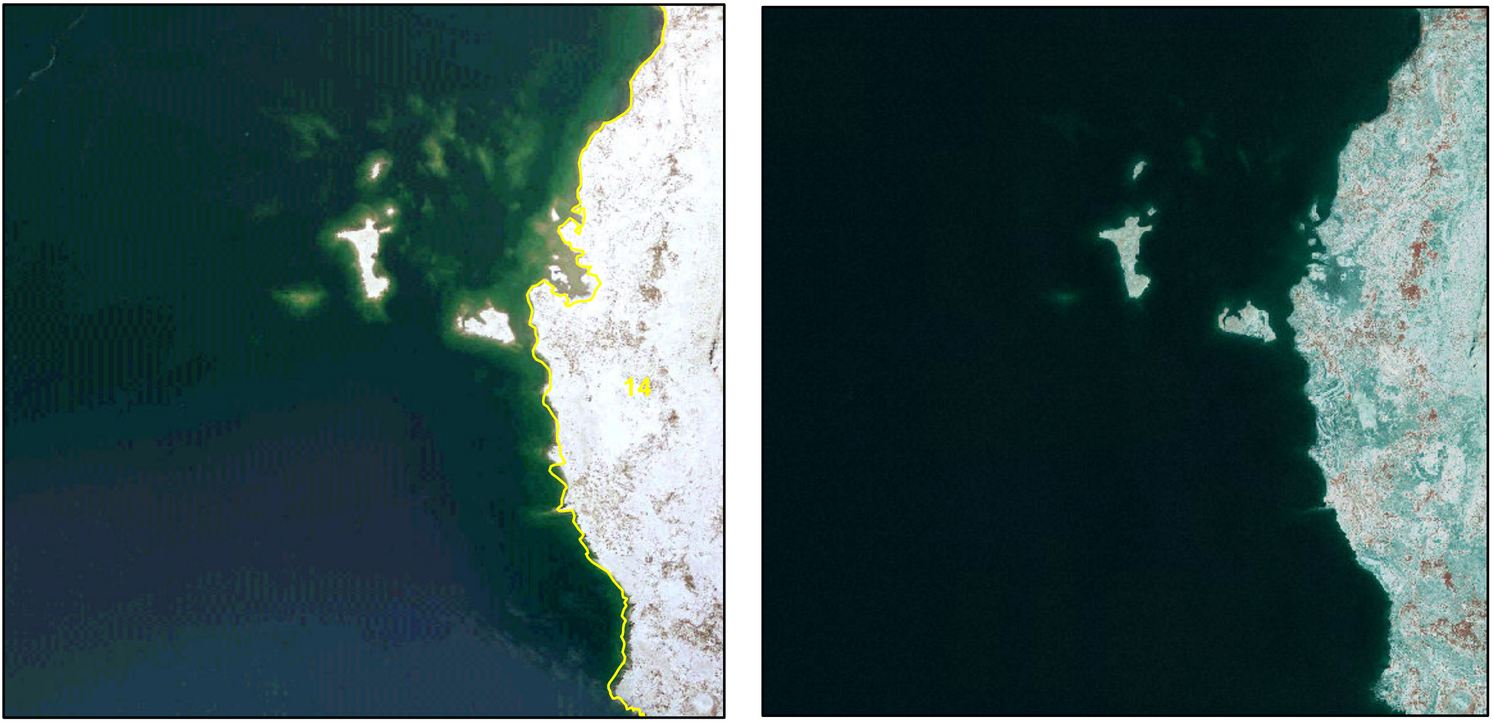
Landtype Legend

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map E1

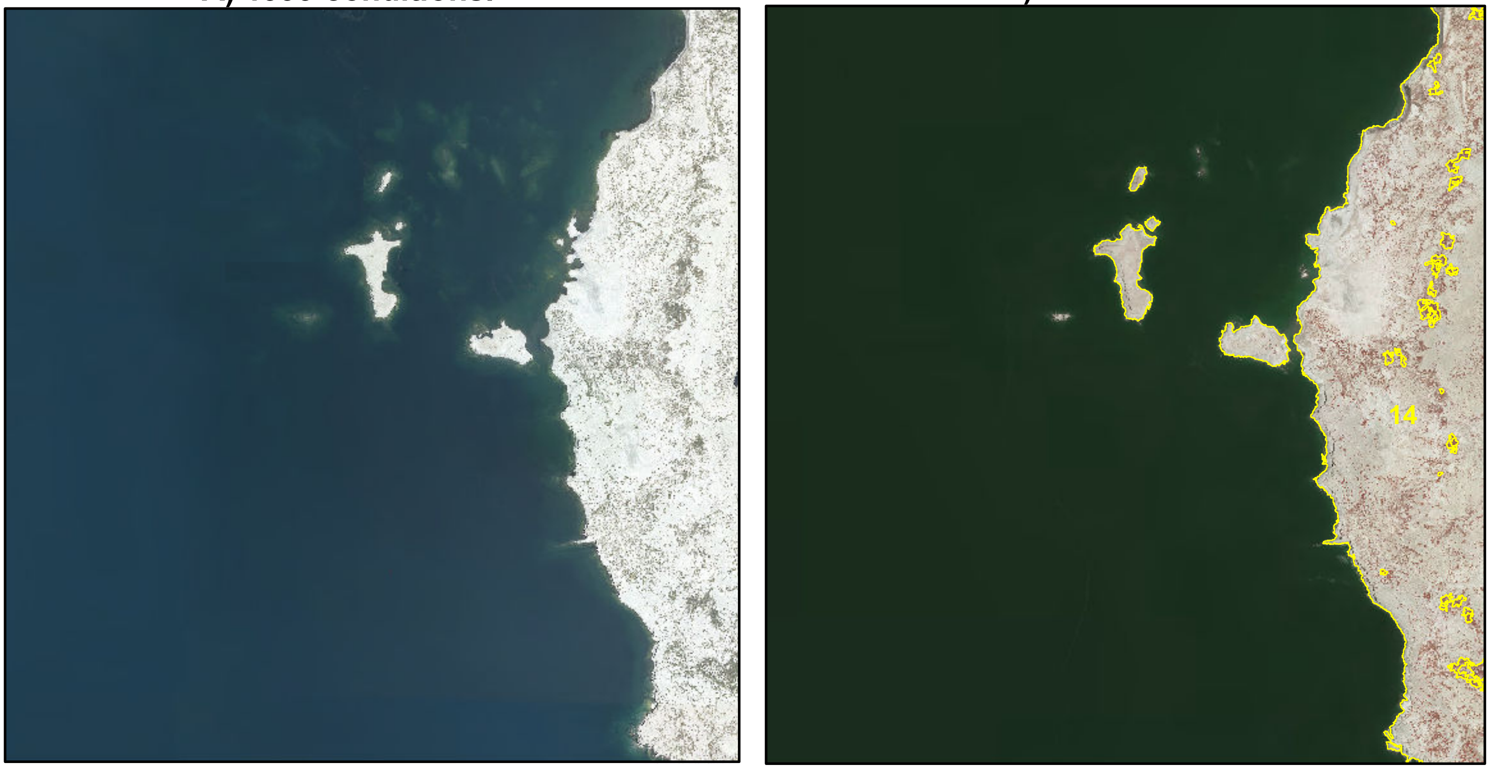


Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.



A) 1999 conditions.

B) 2005 conditions.



C) 2009 conditions.

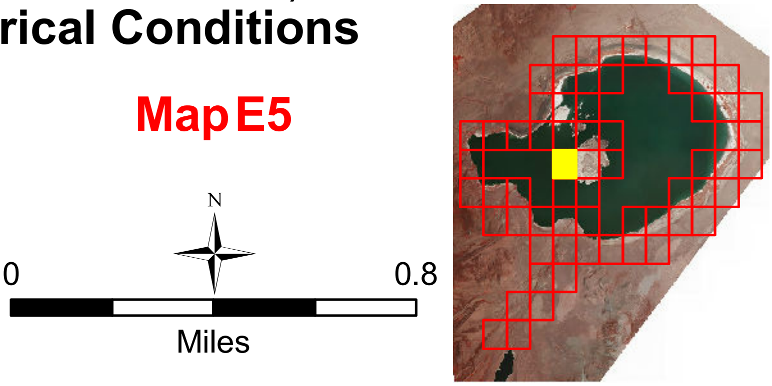
D) 2014 conditions.

Mono Lake Landtype, Historical Conditions

Landtype Legend

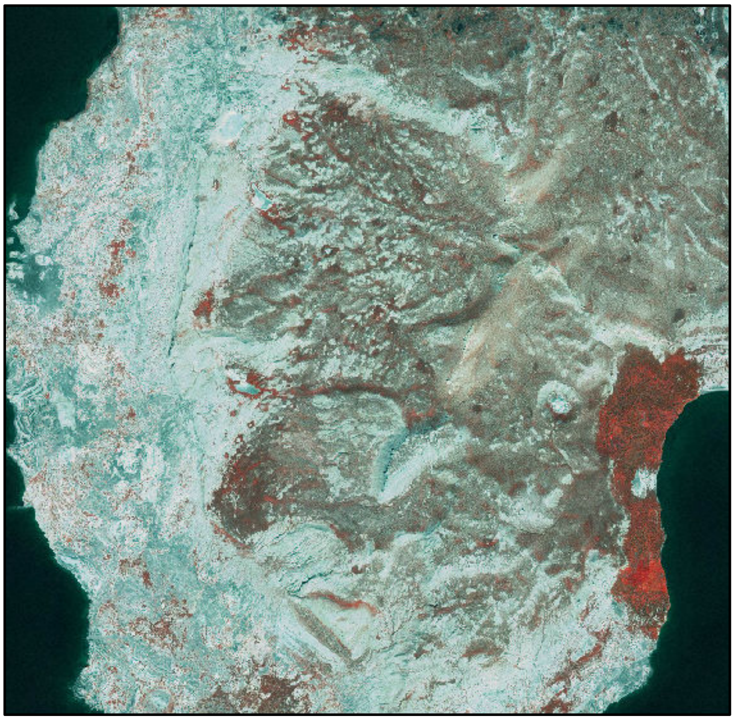
1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map E5



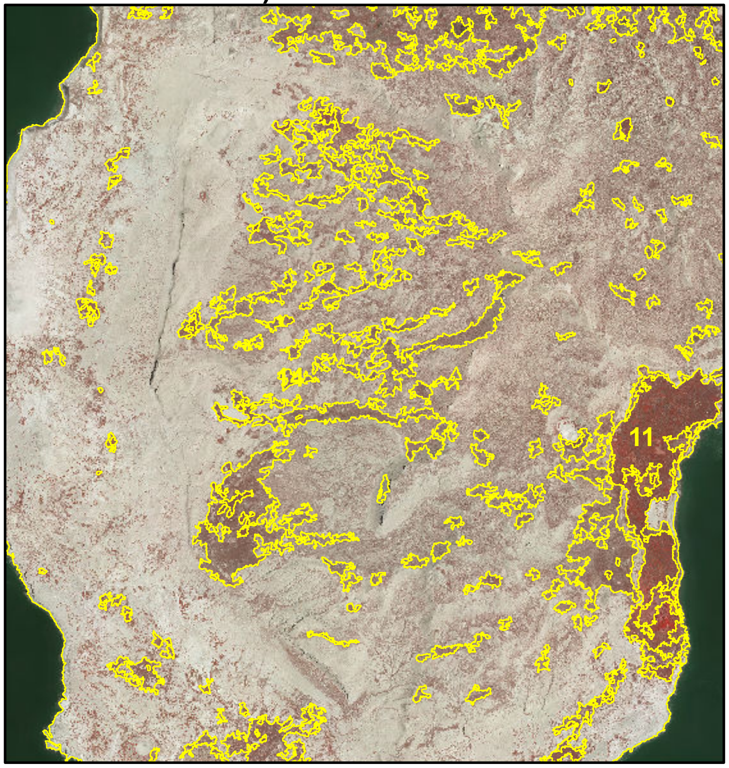
Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.

A) 1999 conditions.



B) 2005 conditions.

C) 2009 conditions.



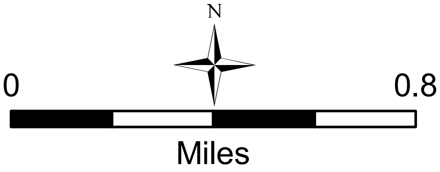
D) 2014 conditions.

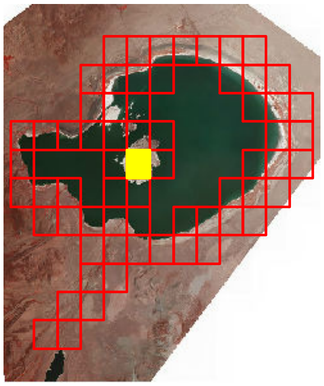
Mono Lake Landtype, Historical Conditions

Landtype Legend

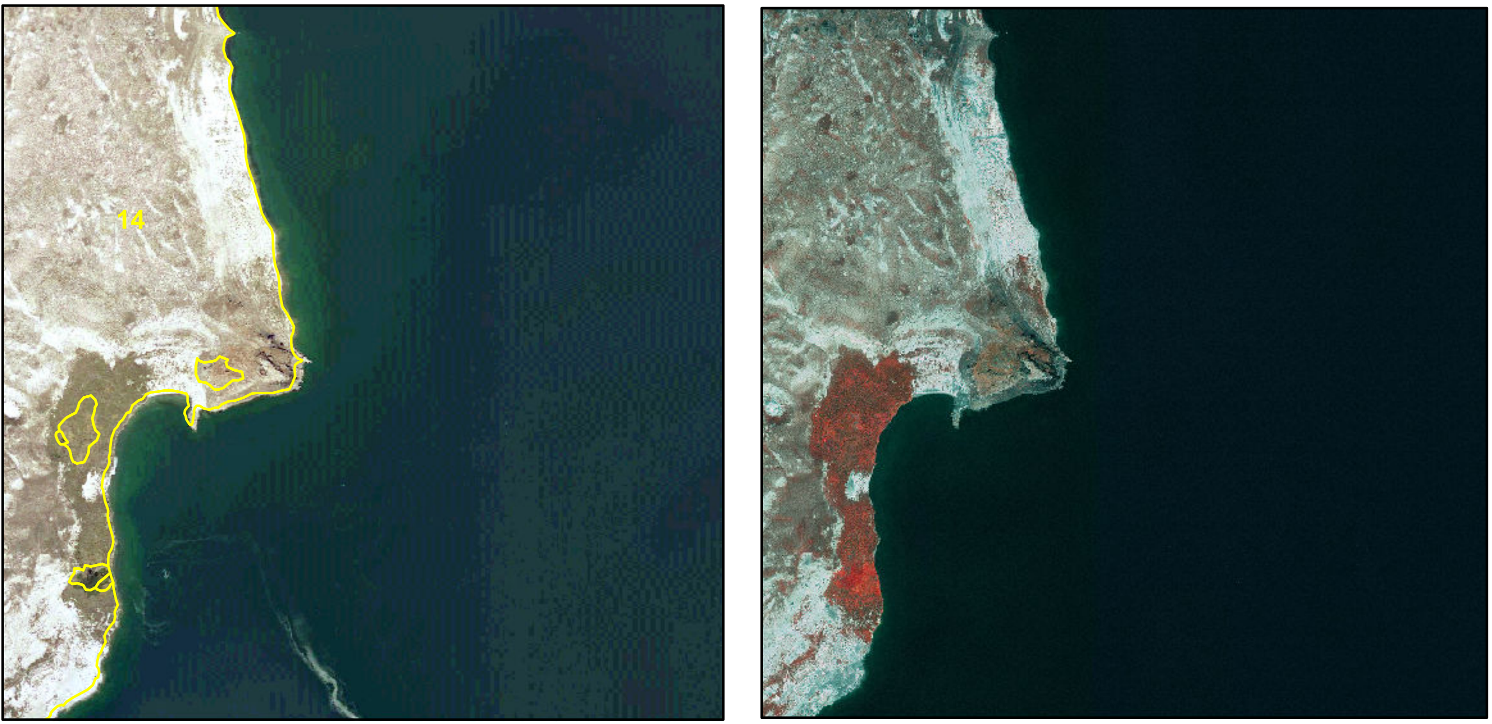
1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map E6



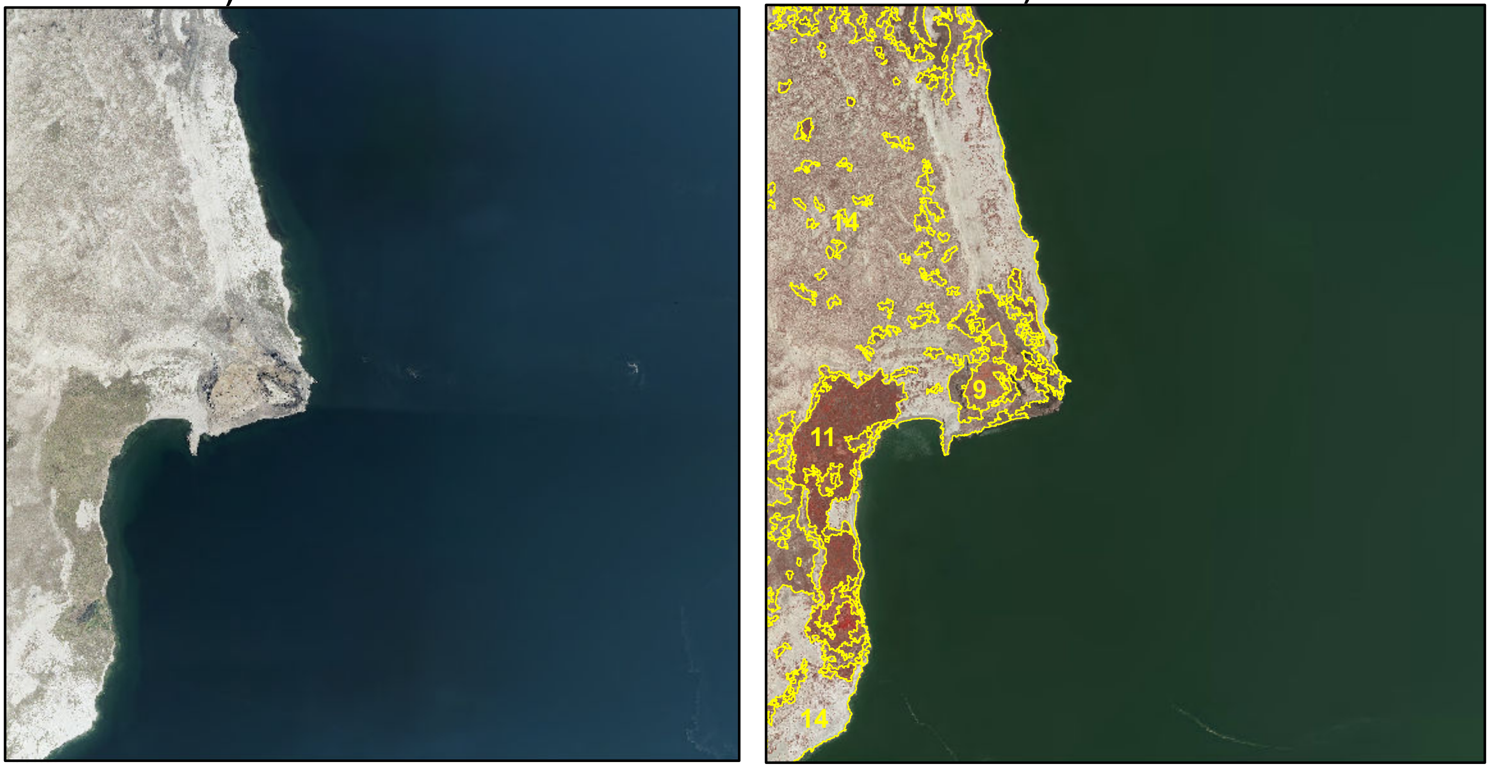


Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.



A) 1999 conditions.

B) 2005 conditions.



C) 2009 conditions.

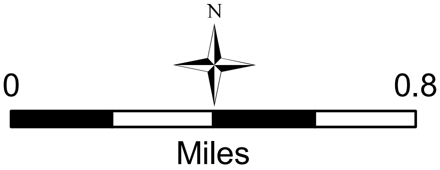
D) 2014 conditions.

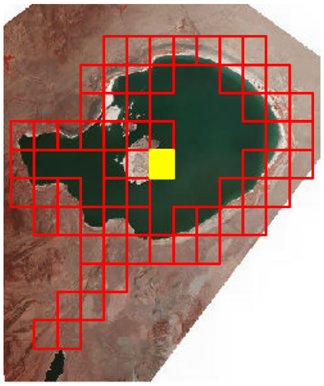
Mono Lake Landtype, Historical Conditions

Landtype Legend

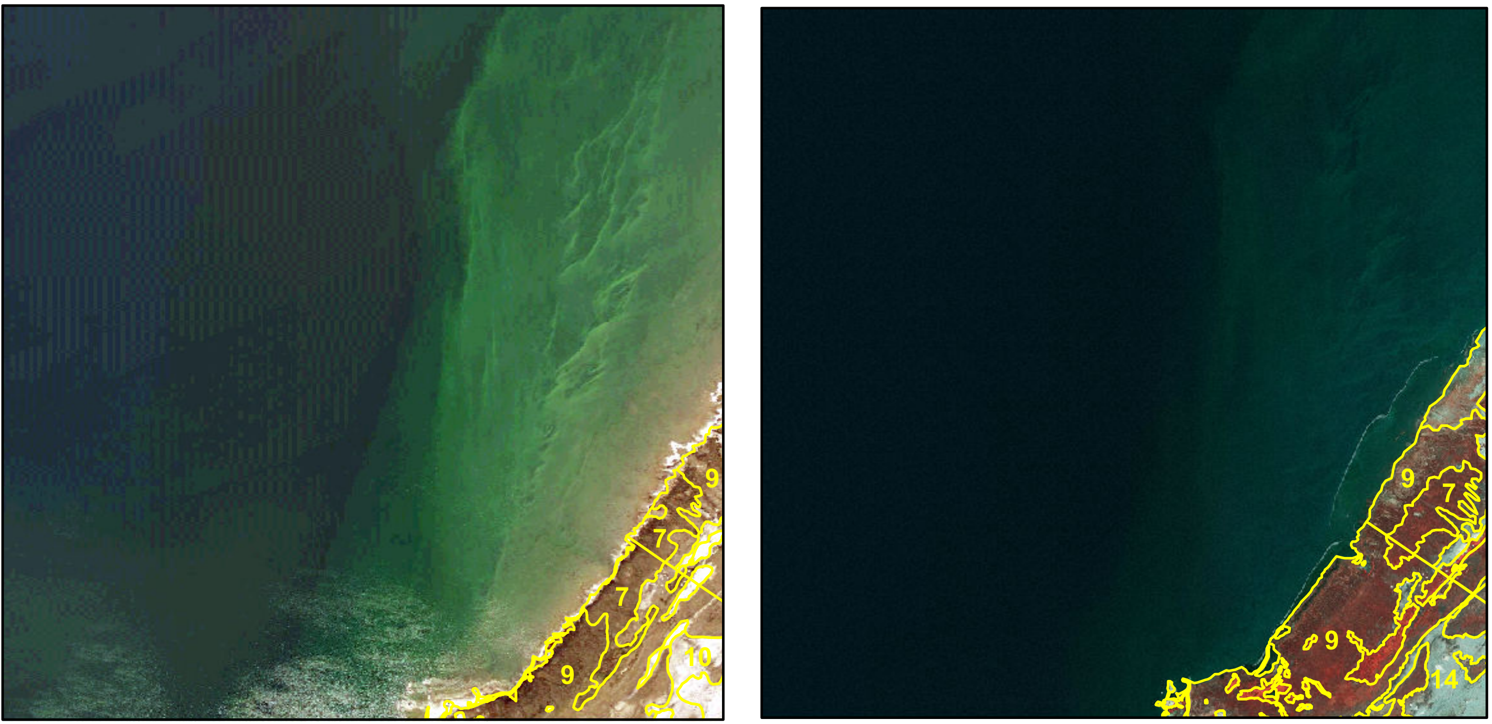
1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map E7



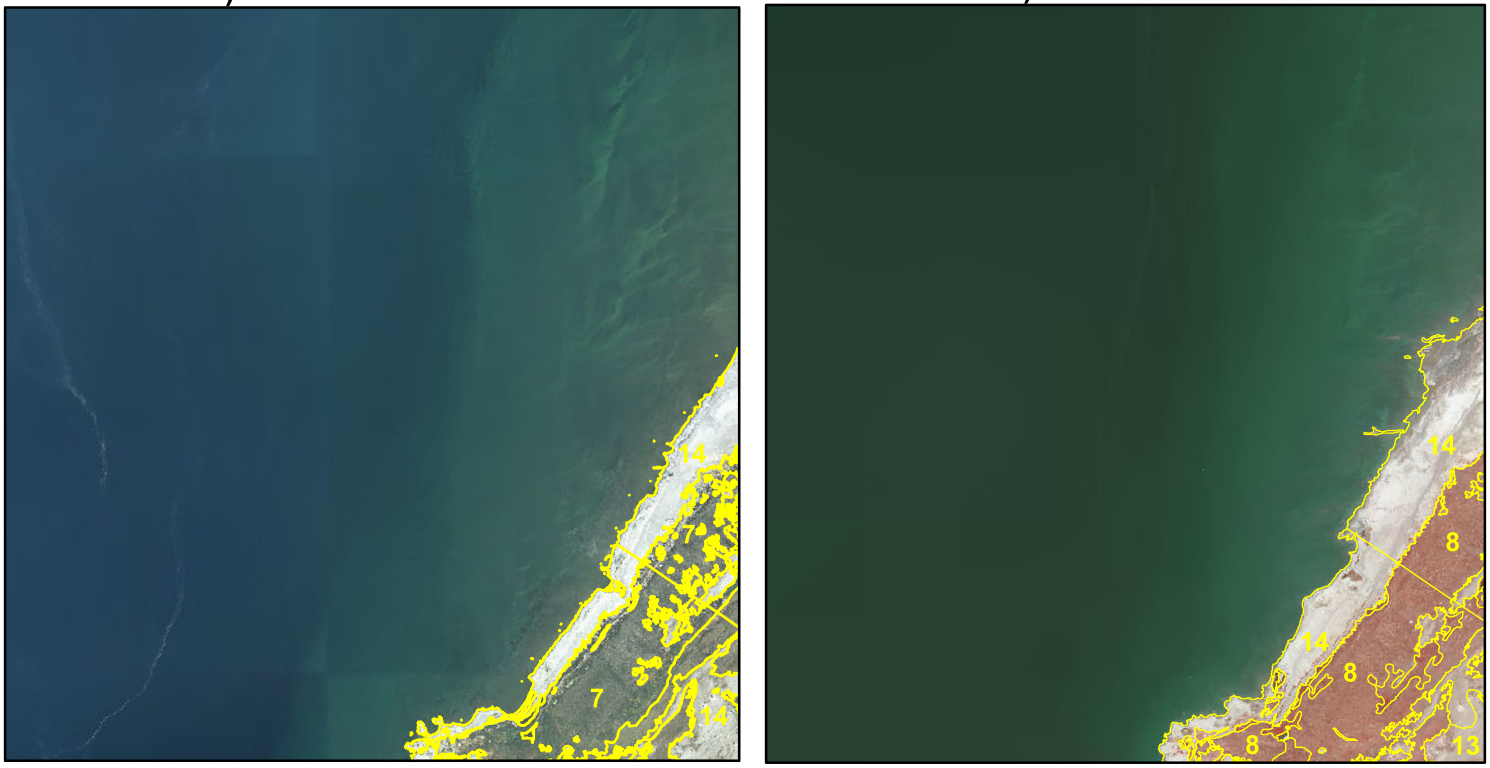


Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.



A) 1999 conditions.

B) 2005 conditions.



C) 2009 conditions.

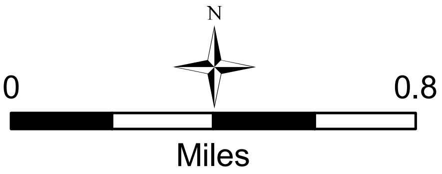
D) 2014 conditions.

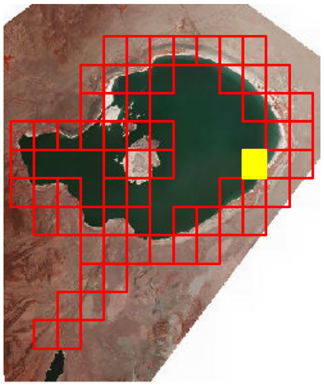
Mono Lake Landtype, Historical Conditions

Landtype Legend

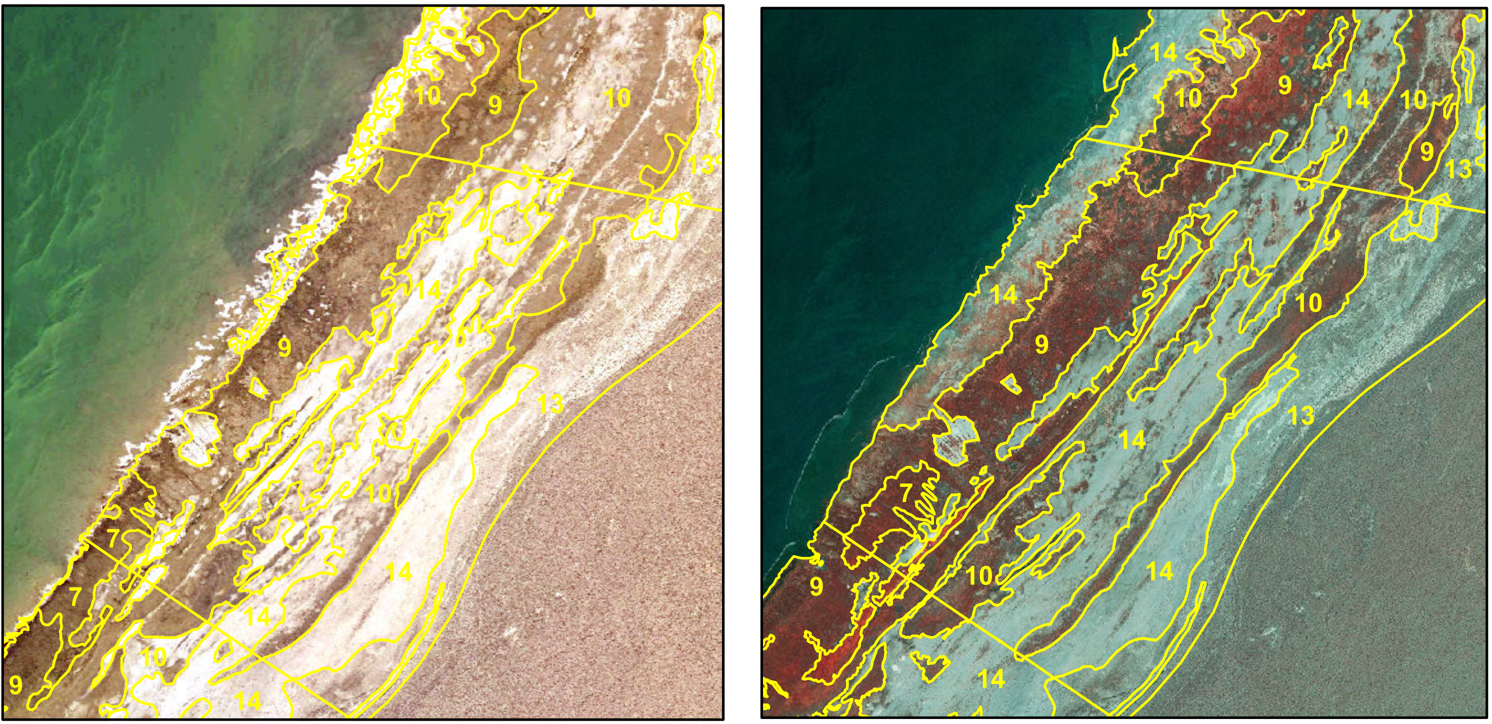
1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map E11



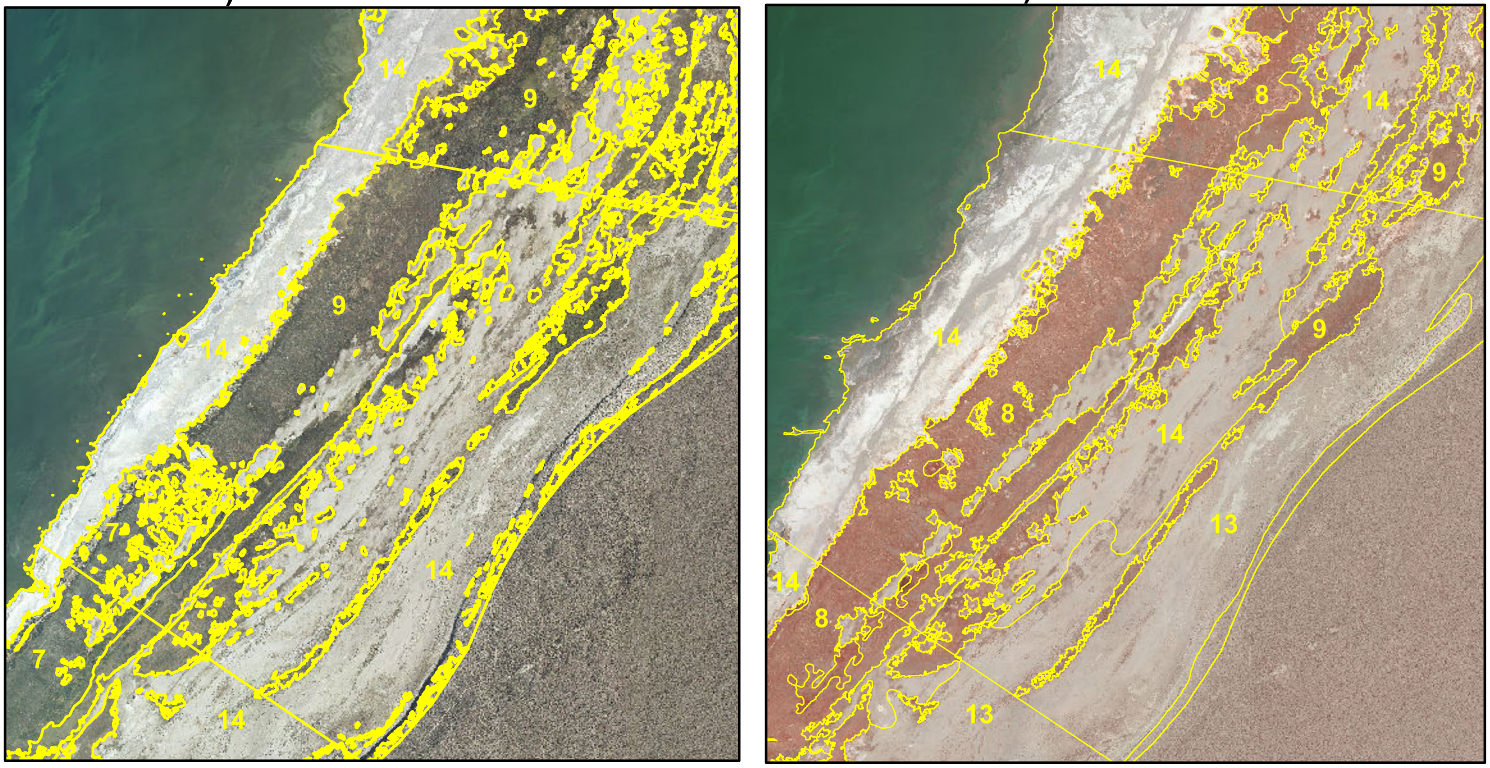


Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.



A) 1999 conditions.

B) 2005 conditions.



C) 2009 conditions.

D) 2014 conditions.

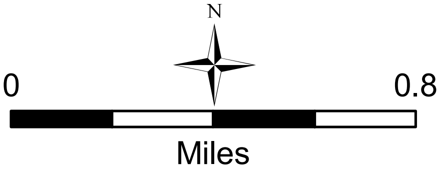
Mono Lake Landtype, Historical Conditions

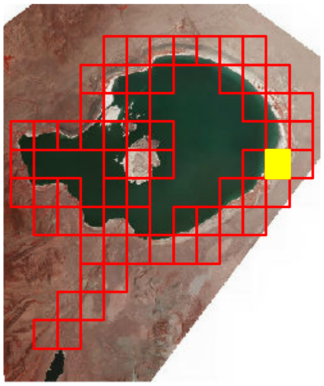
Landtype Legend

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow

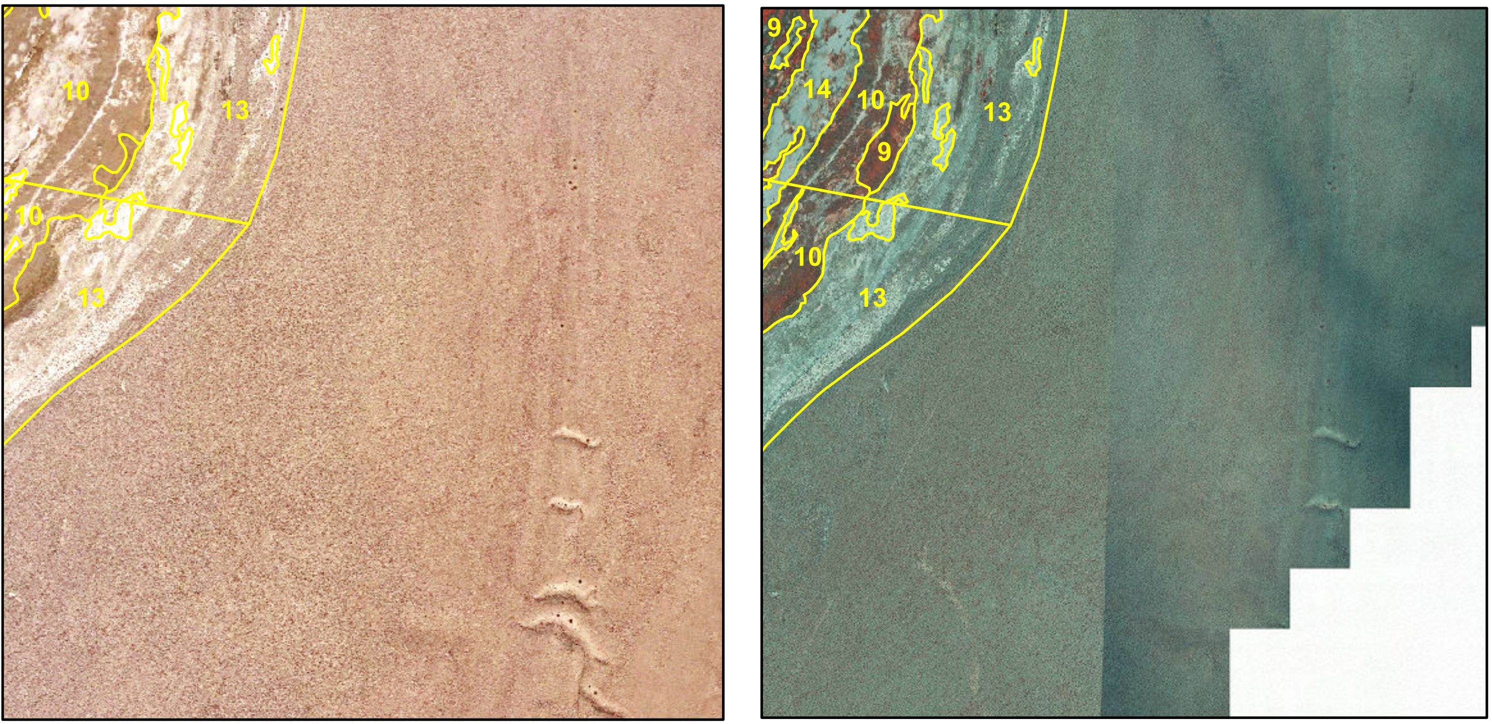
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map E12



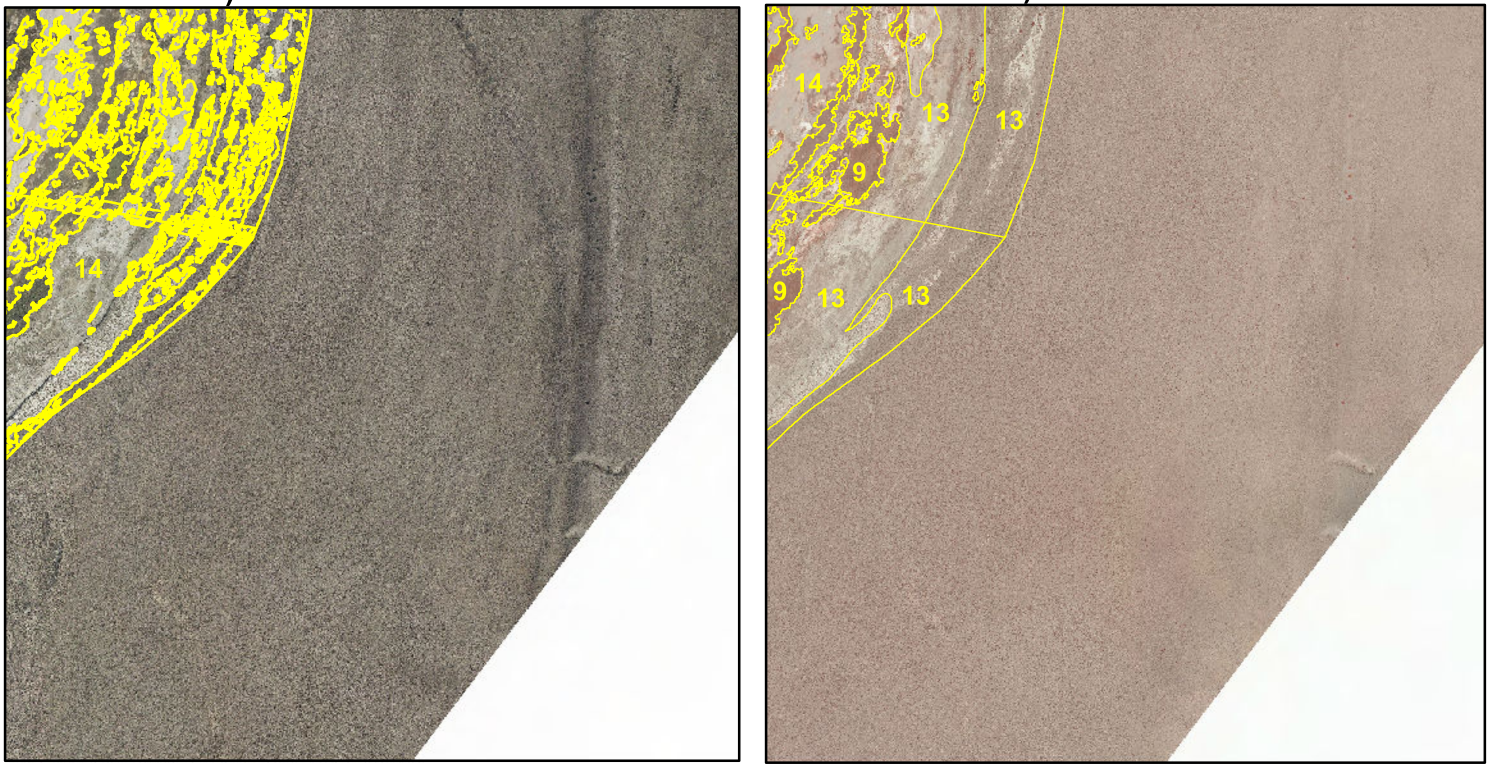


Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.



A) 1999 conditions.

B) 2005 conditions.



C) 2009 conditions.

D) 2014 conditions.

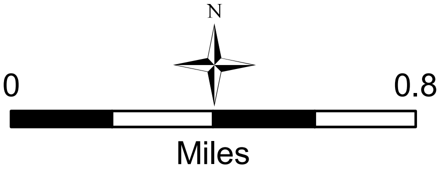
Mono Lake Landtype, Historical Conditions

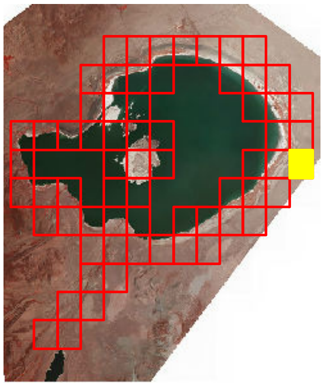
Landtype Legend

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow

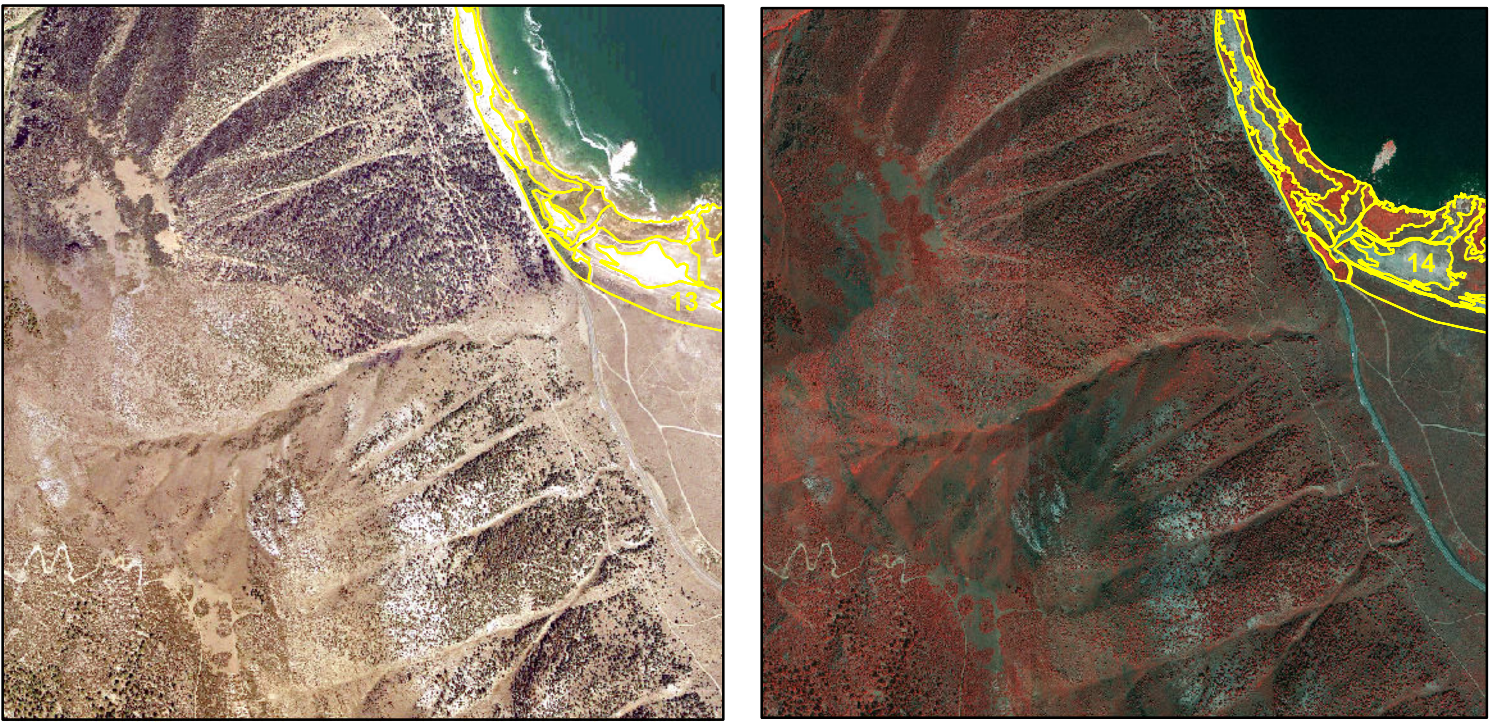
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map E13



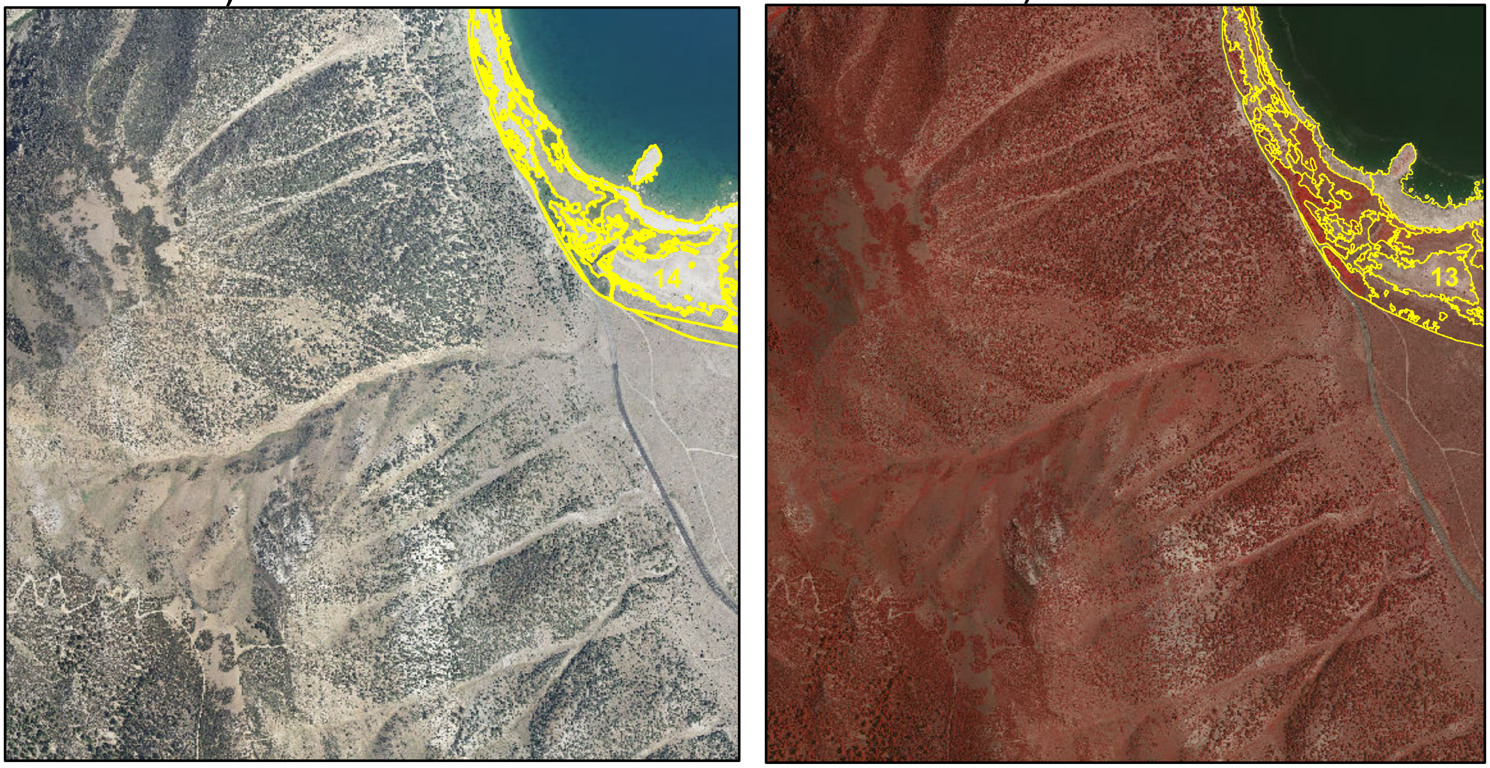


Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.



A) 1999 conditions.

B) 2005 conditions.



C) 2009 conditions.

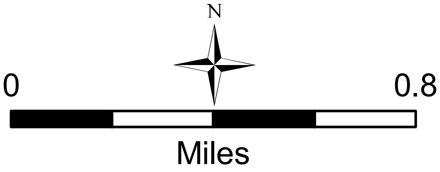
D) 2014 conditions.

Mono Lake Landtype, Historical Conditions

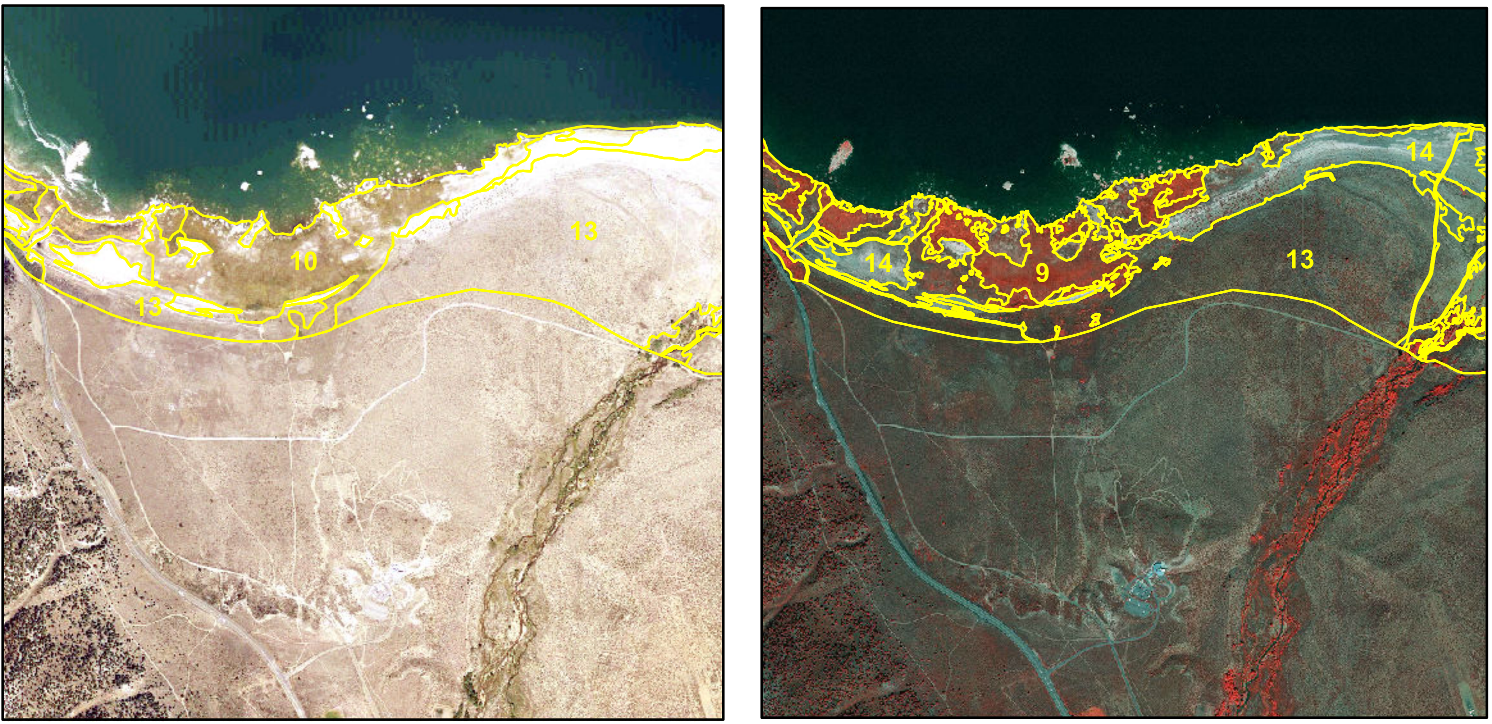
Landtype Legend

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map F1

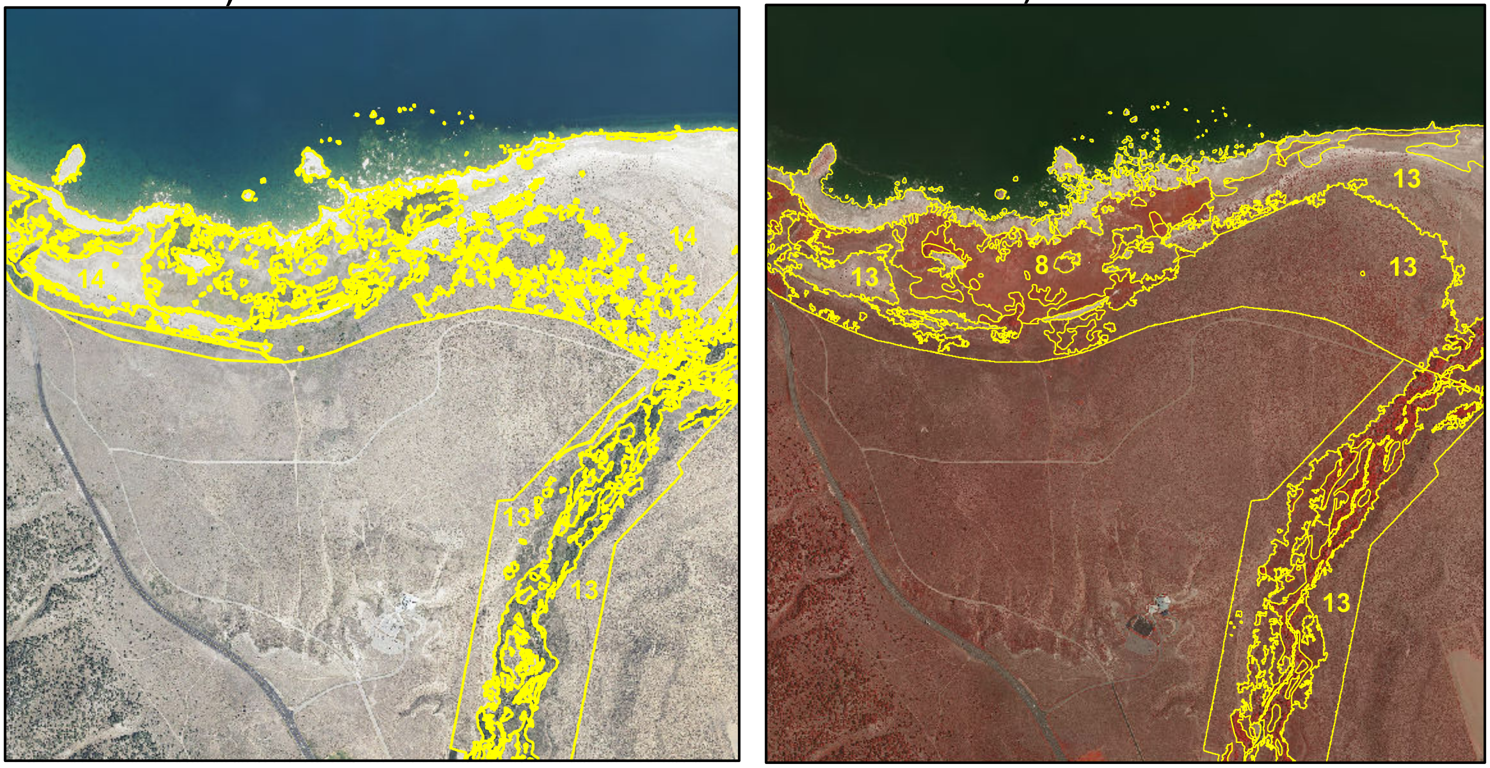


Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.



A) 1999 conditions.

B) 2005 conditions.



C) 2009 conditions.

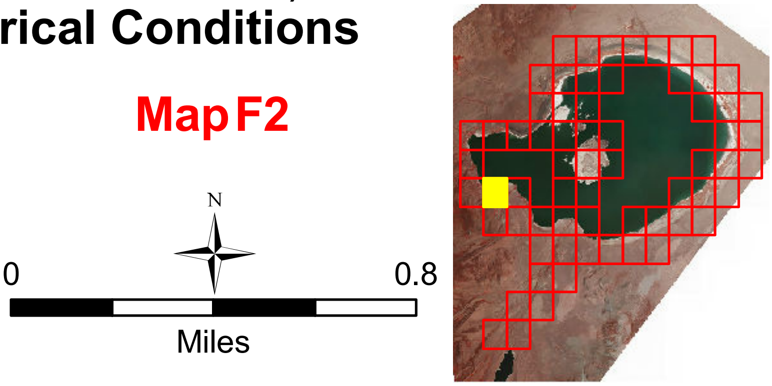
D) 2014 conditions.

Mono Lake Landtype, Historical Conditions

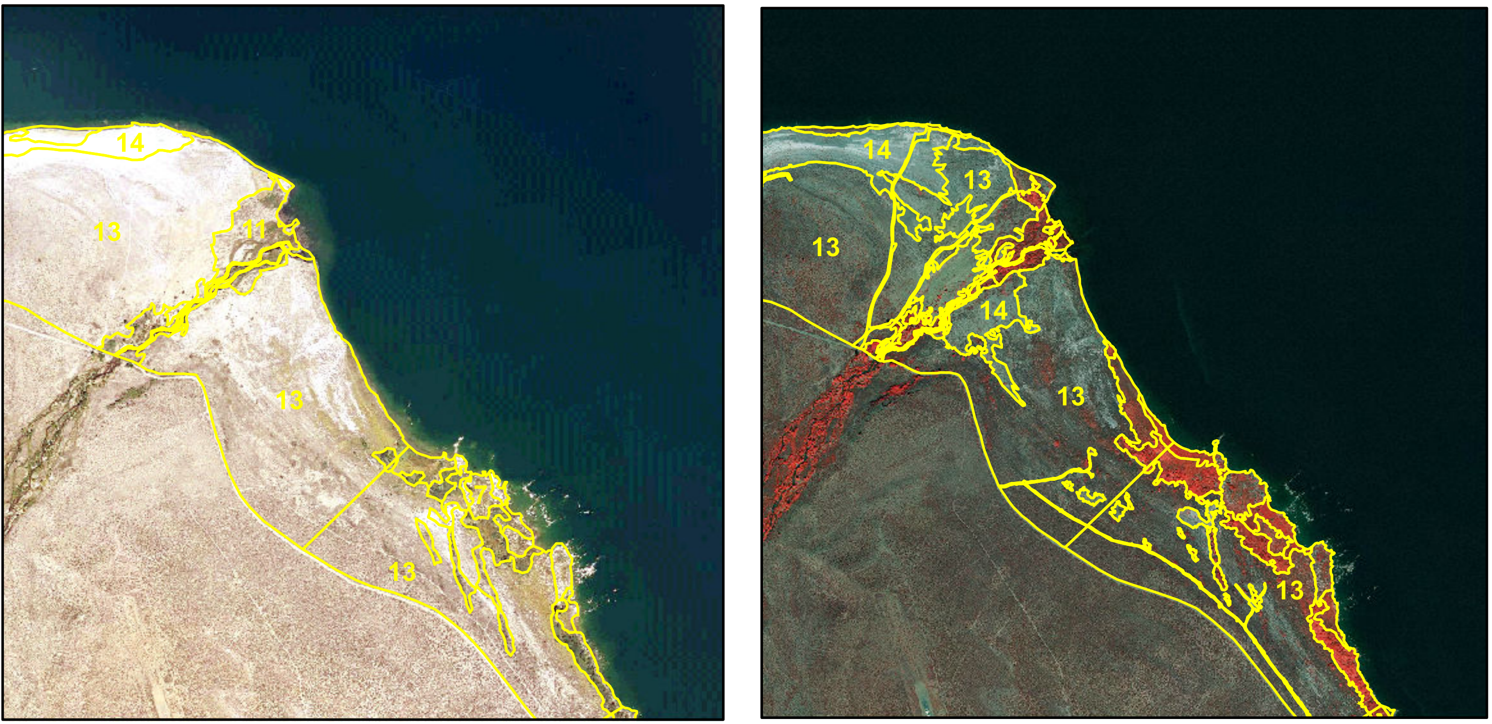
Landtype Legend

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map F2

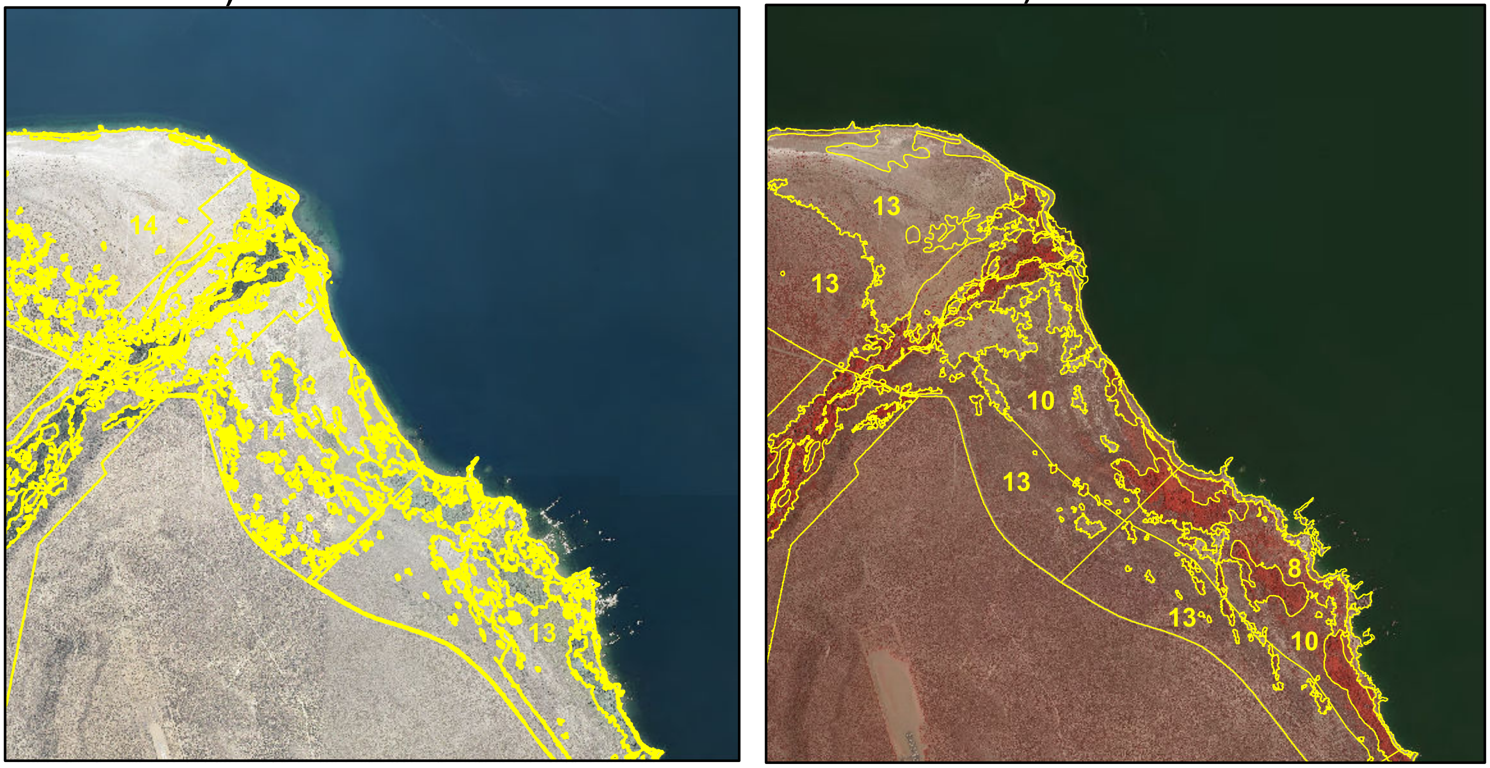


Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.



A) 1999 conditions.

B) 2005 conditions.



C) 2009 conditions.

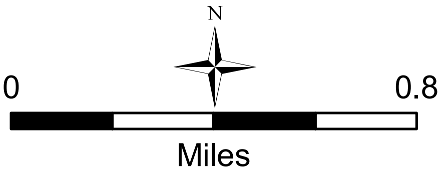
D) 2014 conditions.

Mono Lake Landtype, Historical Conditions

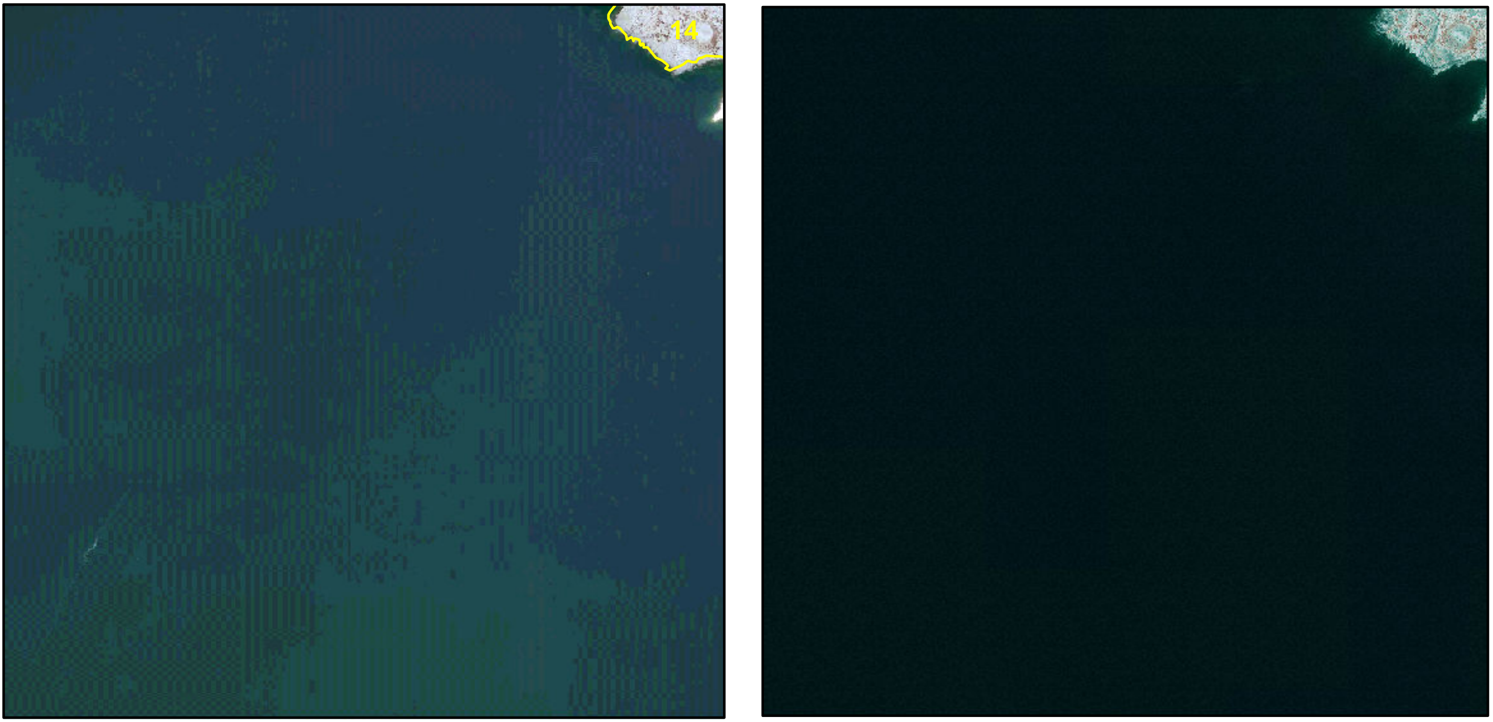
Landtype Legend

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map F3



Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.



A) 1999 conditions.

B) 2005 conditions.

C) 2009 conditions.

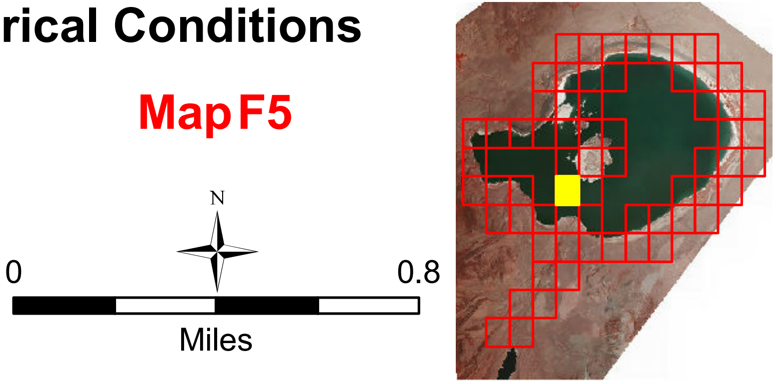
D) 2014 conditions.

Mono Lake Landtype, Historical Conditions

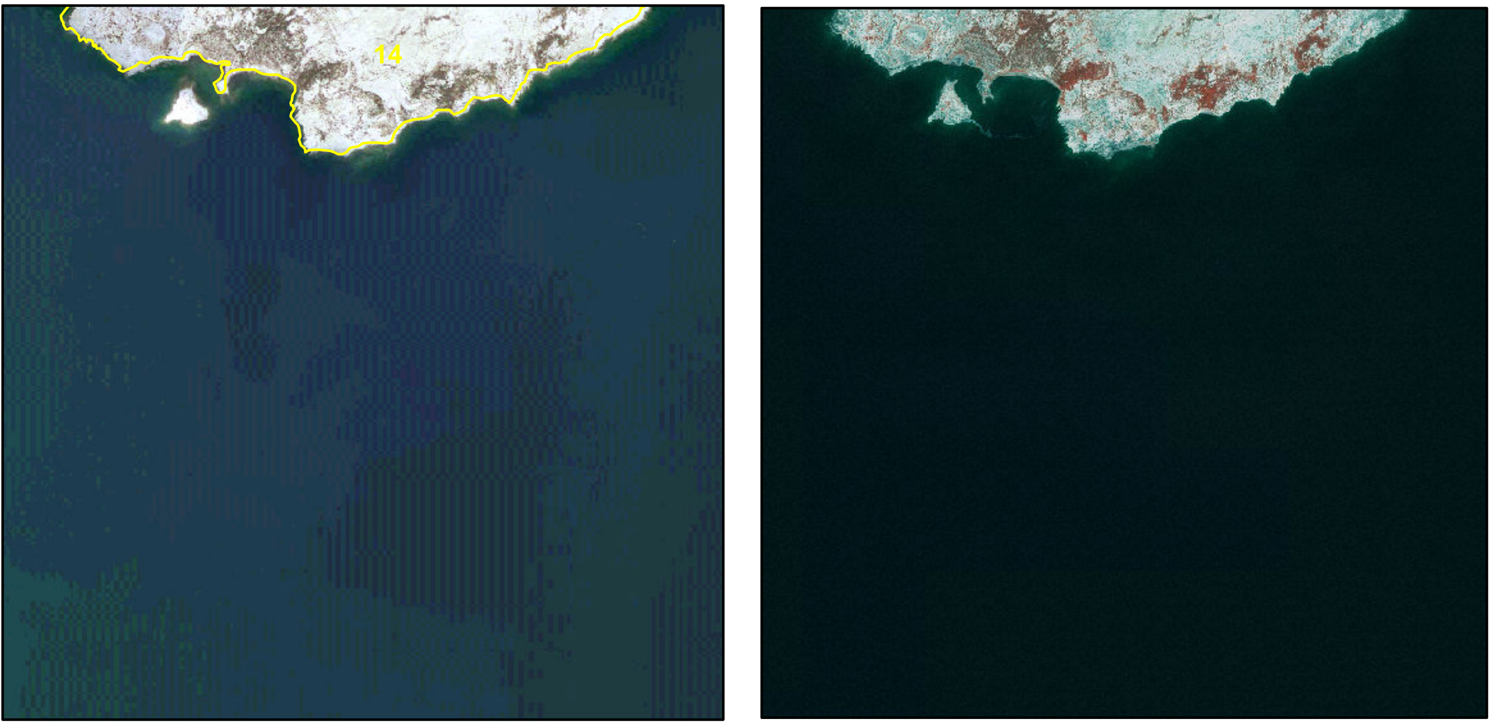
Landtype Legend

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map F5

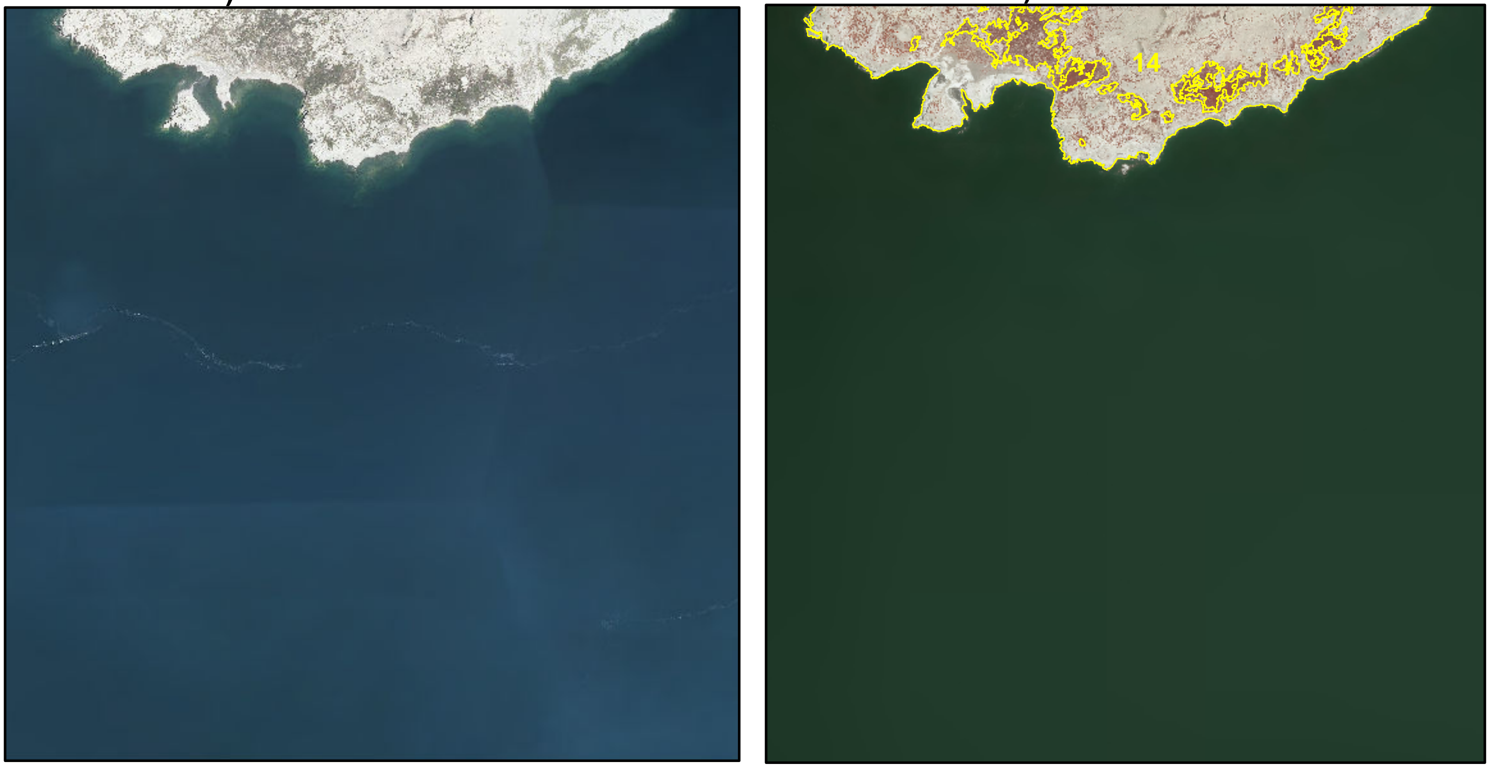


Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.



A) 1999 conditions.

B) 2005 conditions.



C) 2009 conditions.

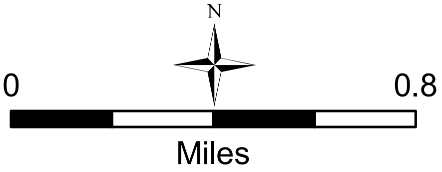
D) 2014 conditions.

Mono Lake Landtype, Historical Conditions

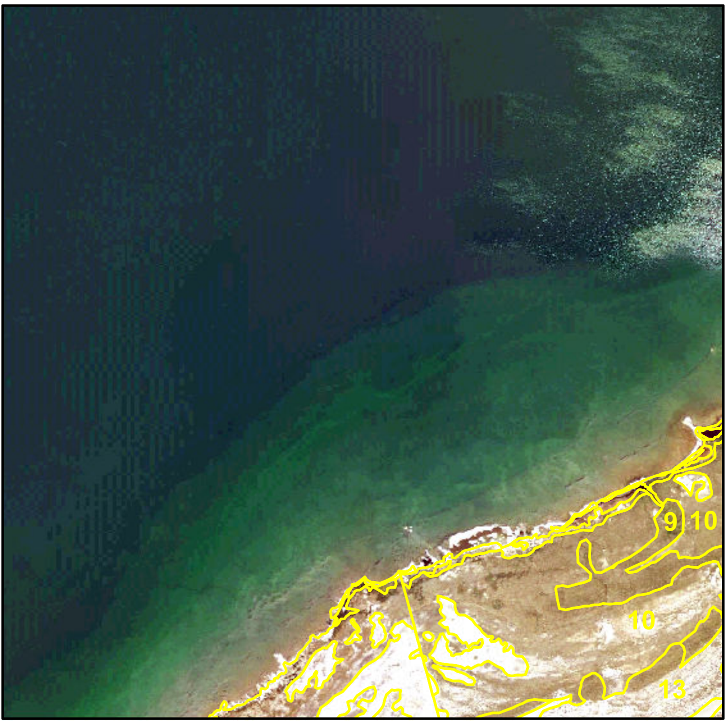
Landtype Legend

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

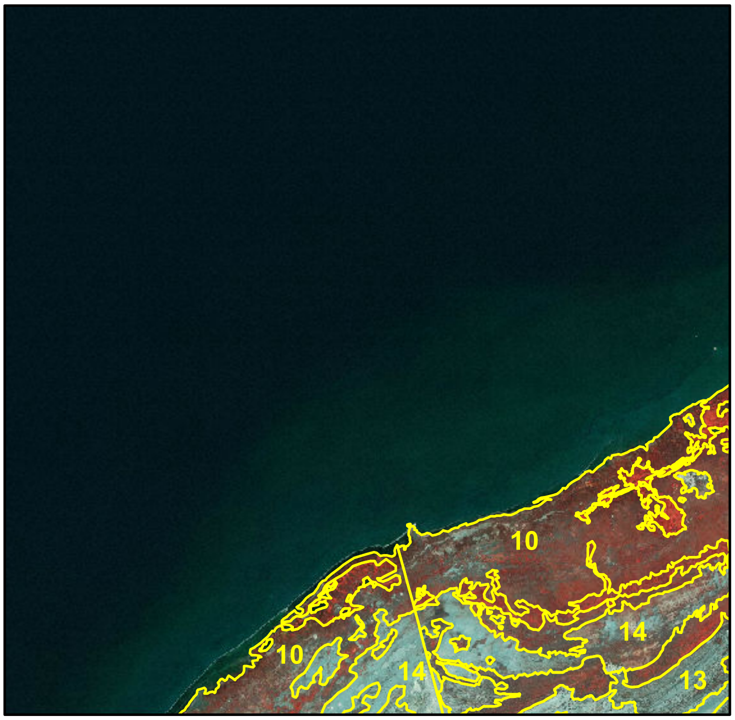
Map F6



Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.

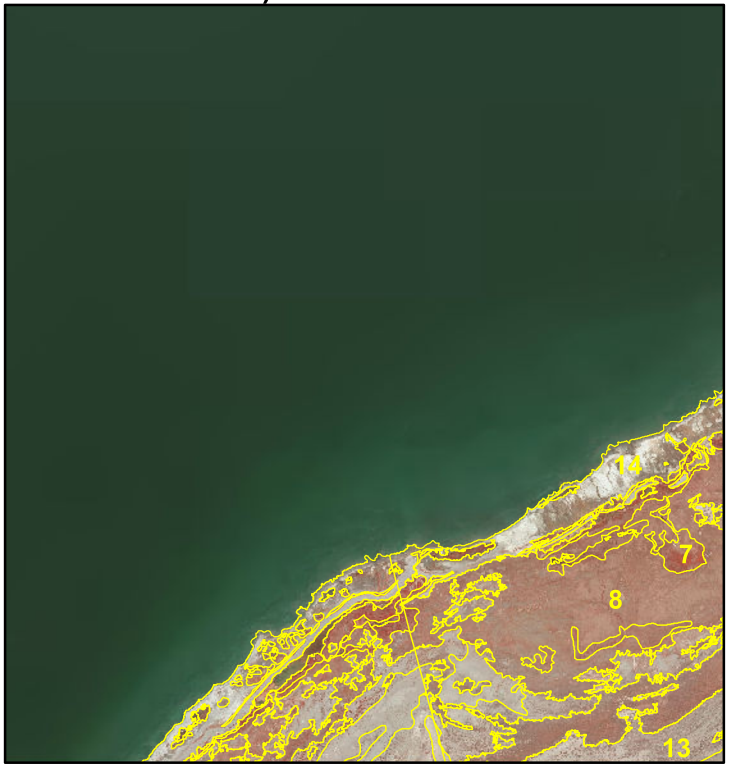


A) 1999 conditions.



B) 2005 conditions.

C) 2009 conditions.



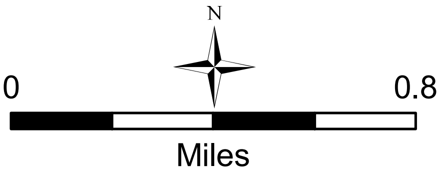
D) 2014 conditions.

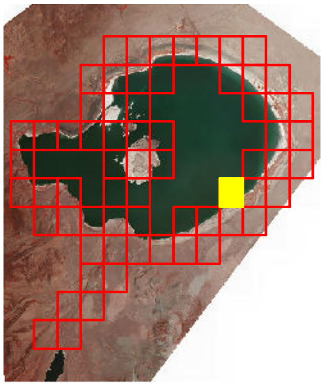
Mono Lake Landtype, Historical Conditions

Landtype Legend

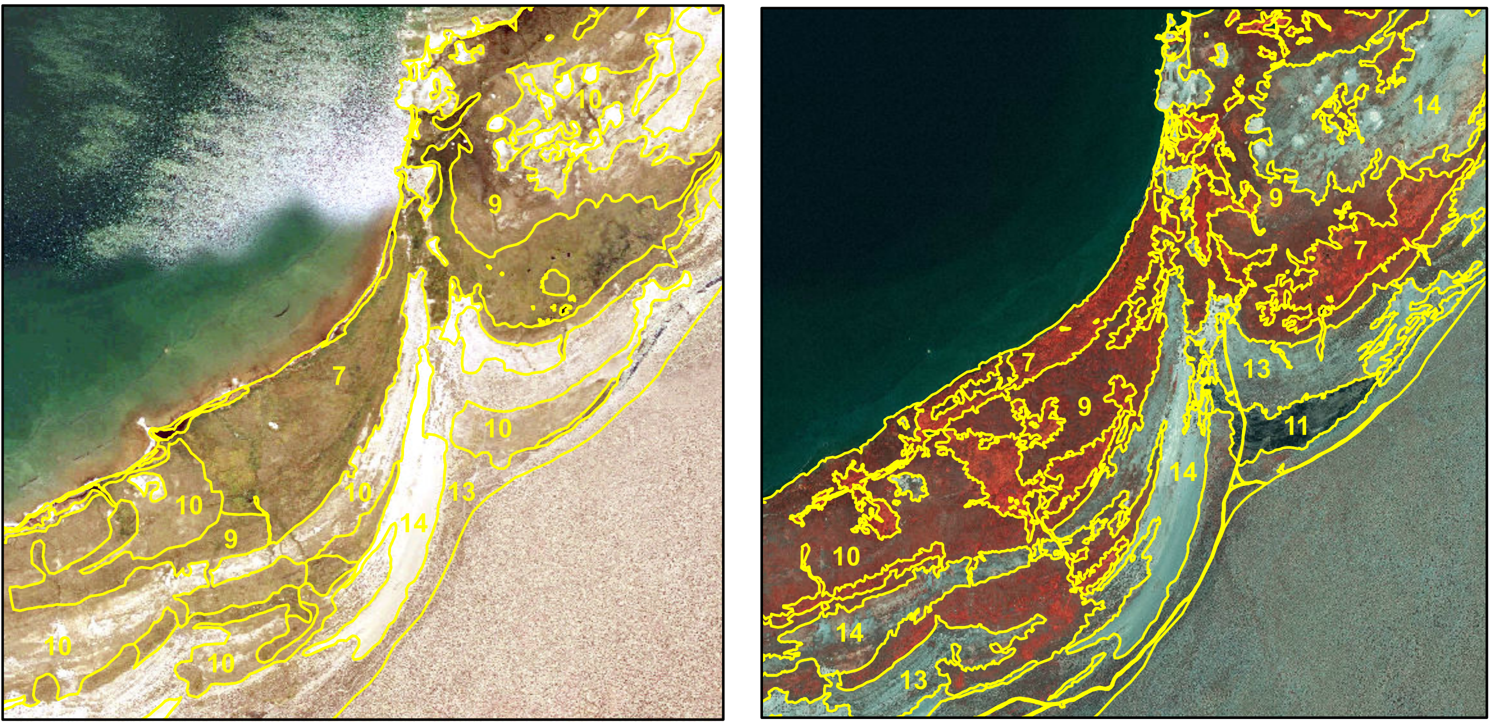
1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map F10



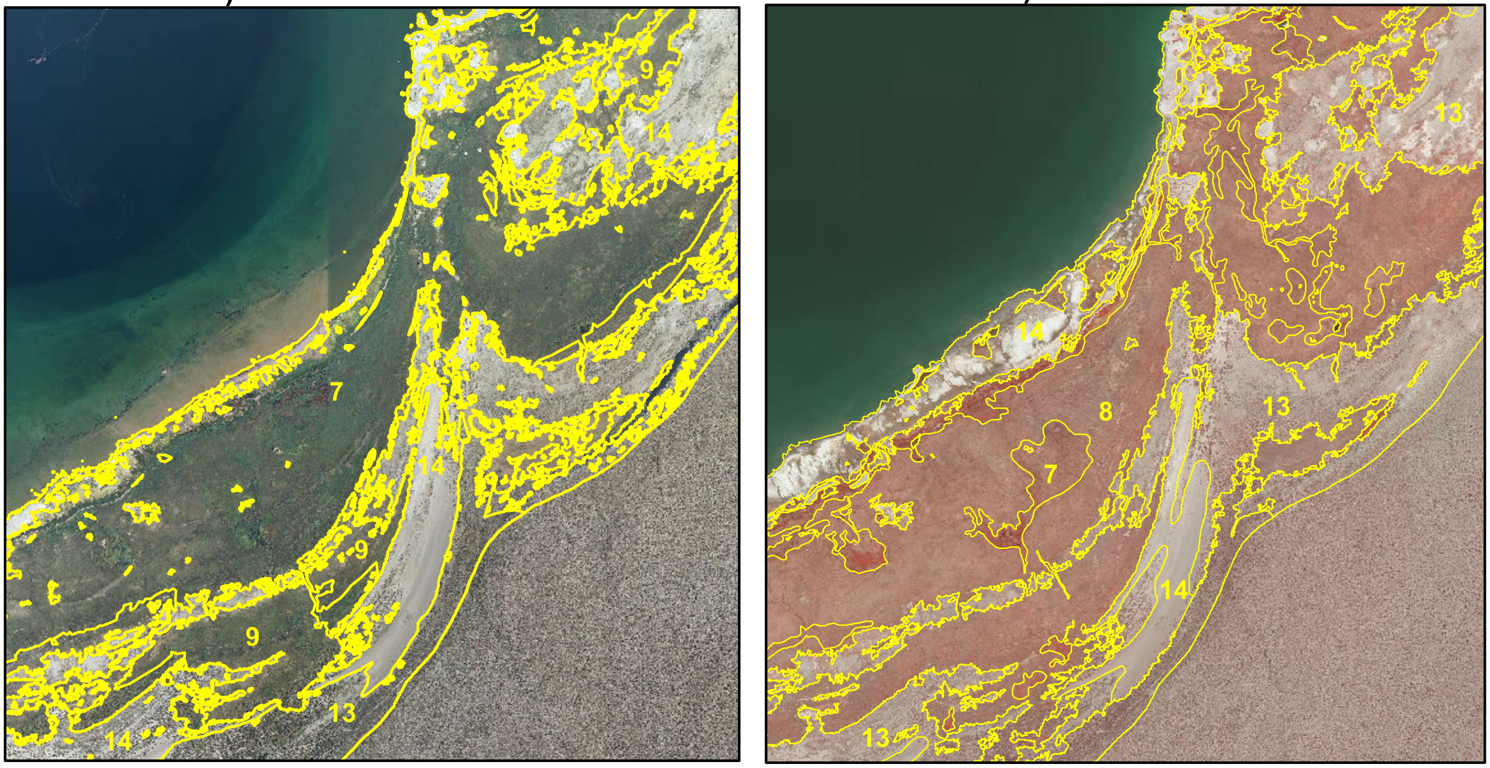


Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.



A) 1999 conditions.

B) 2005 conditions.



C) 2009 conditions.

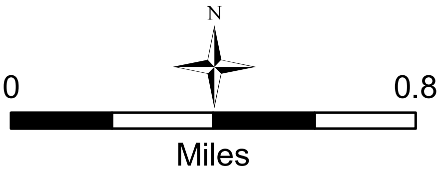
D) 2014 conditions.

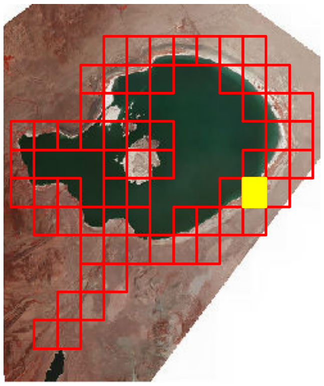
Mono Lake Landtype, Historical Conditions

Landtype Legend

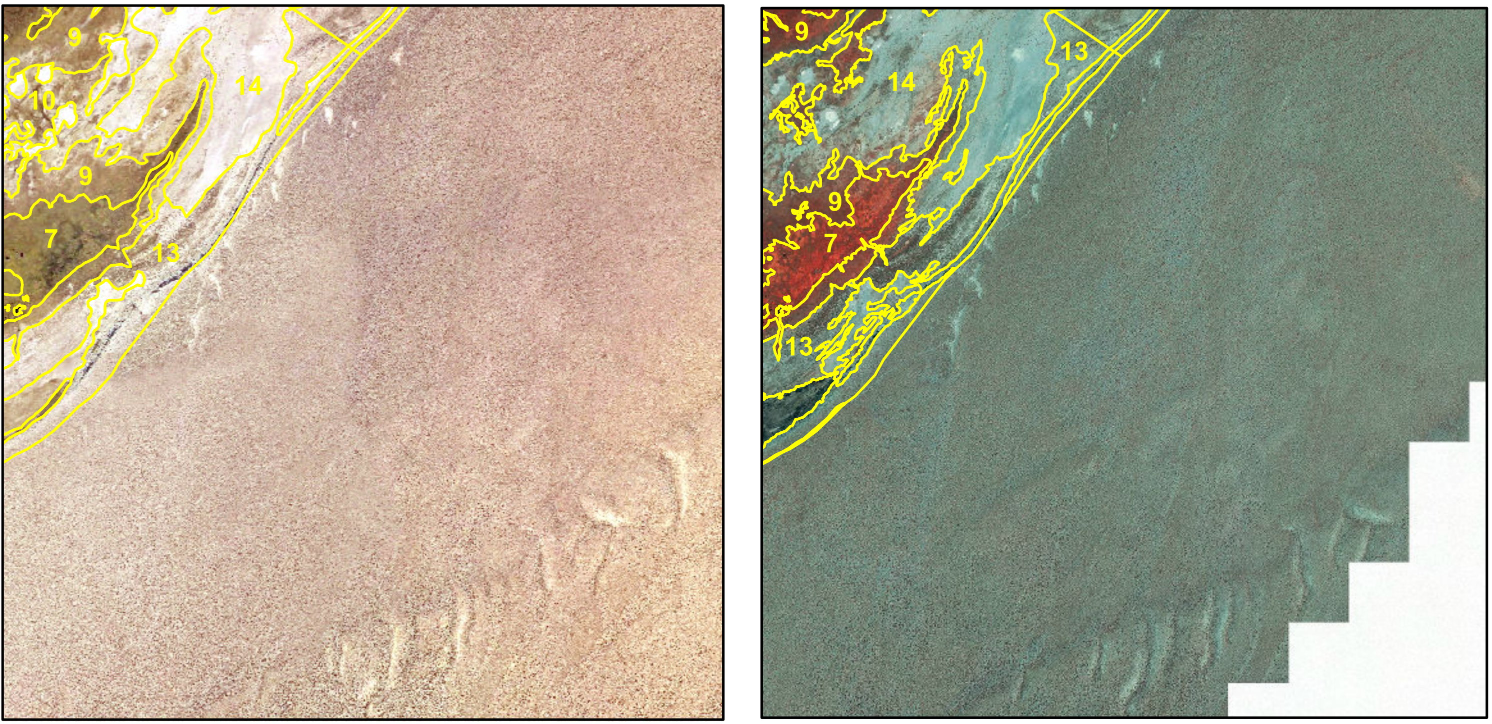
1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map F11



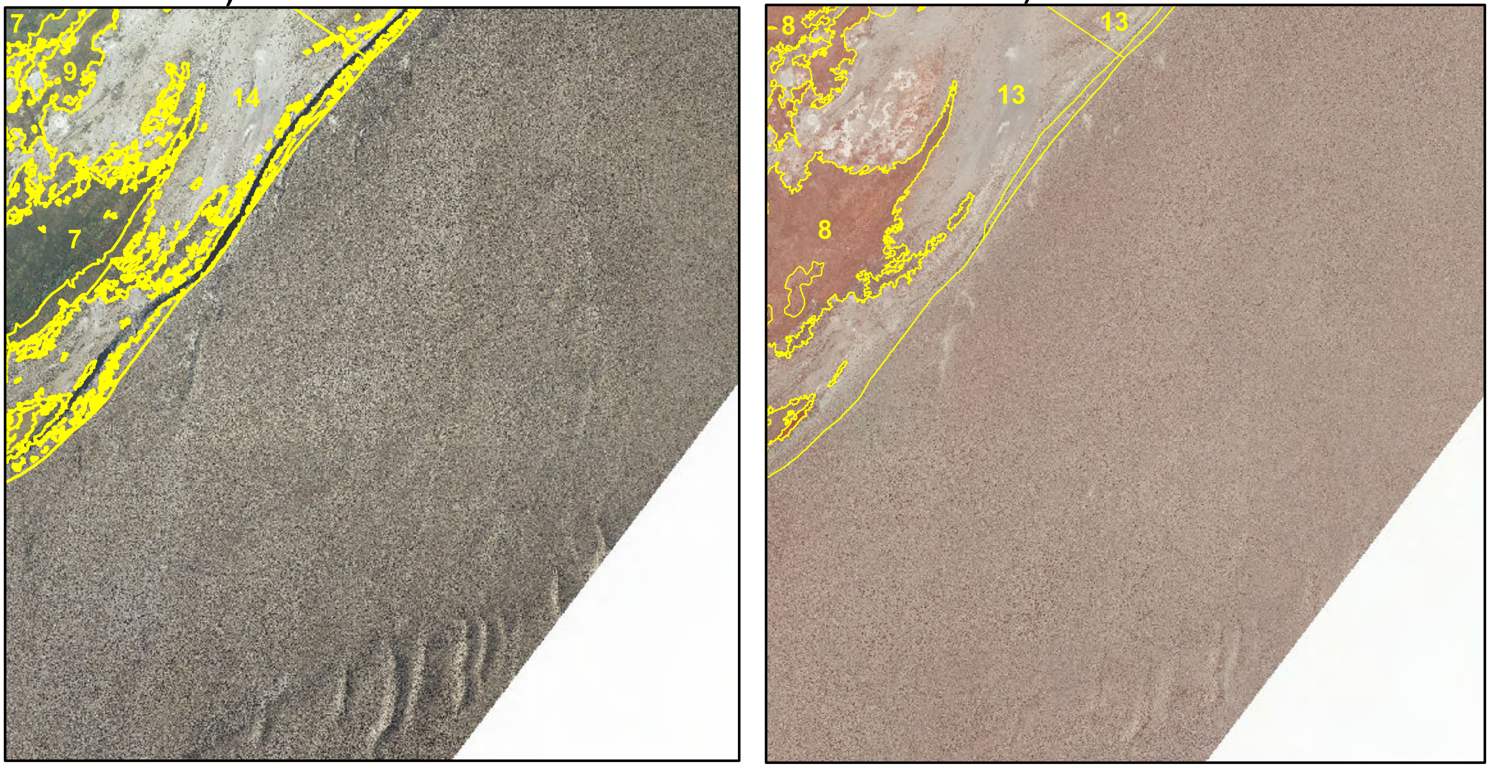


Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.



A) 1999 conditions.

B) 2005 conditions.



C) 2009 conditions.

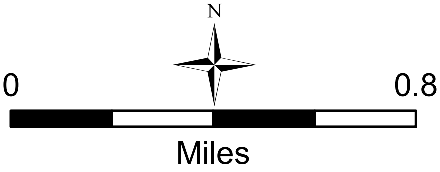
D) 2014 conditions.

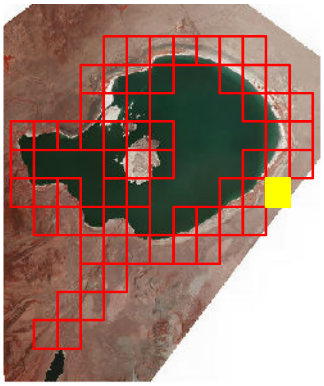
Mono Lake Landtype, Historical Conditions

Landtype Legend

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map F12

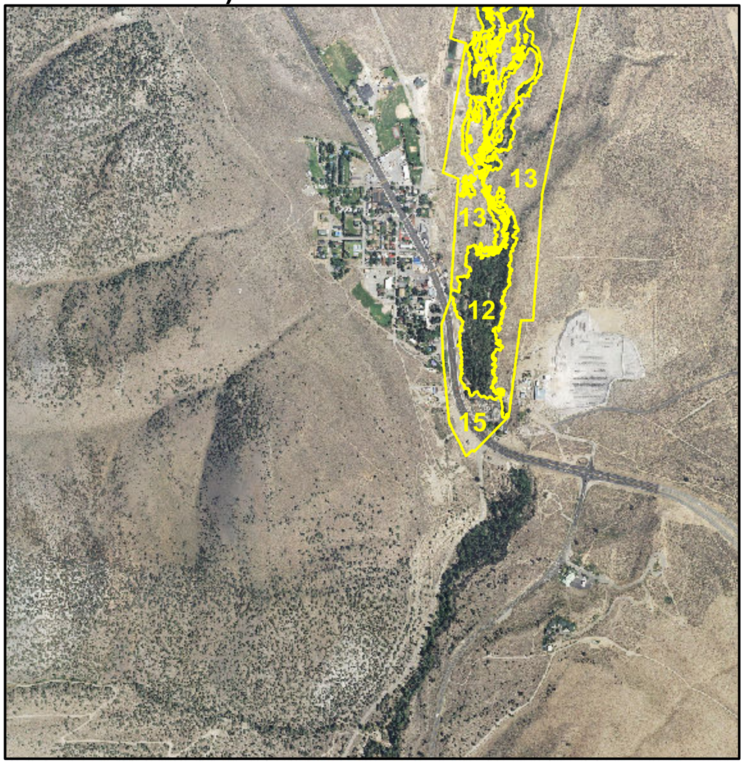




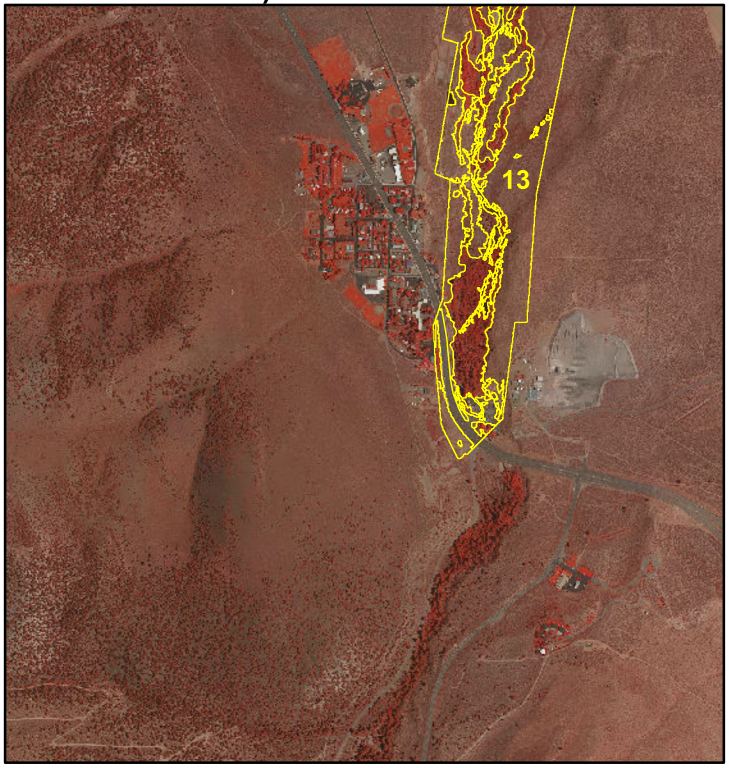
Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.

A) 1999 conditions.

B) 2005 conditions.



C) 2009 conditions.



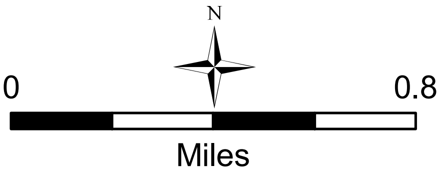
D) 2014 conditions.

Mono Lake Landtype, Historical Conditions

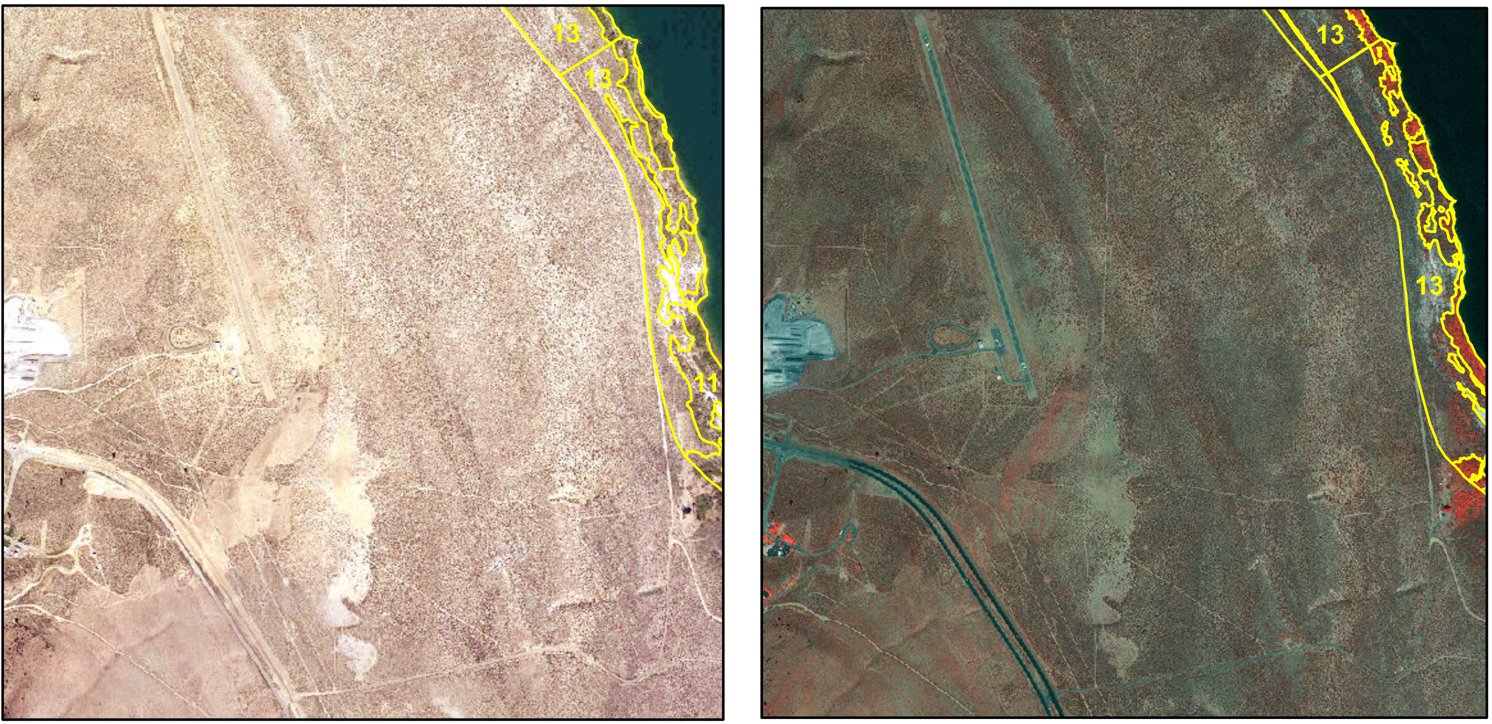
Landtype Legend

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map G2



Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.



A) 1999 conditions.

B) 2005 conditions.

C) 2009 conditions.

D) 2014 conditions.

Mono Lake Landtype, Historical Conditions

Landtype Legend

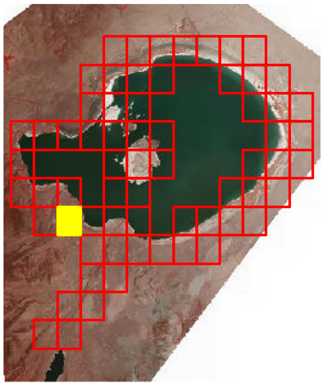
1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map G3

N

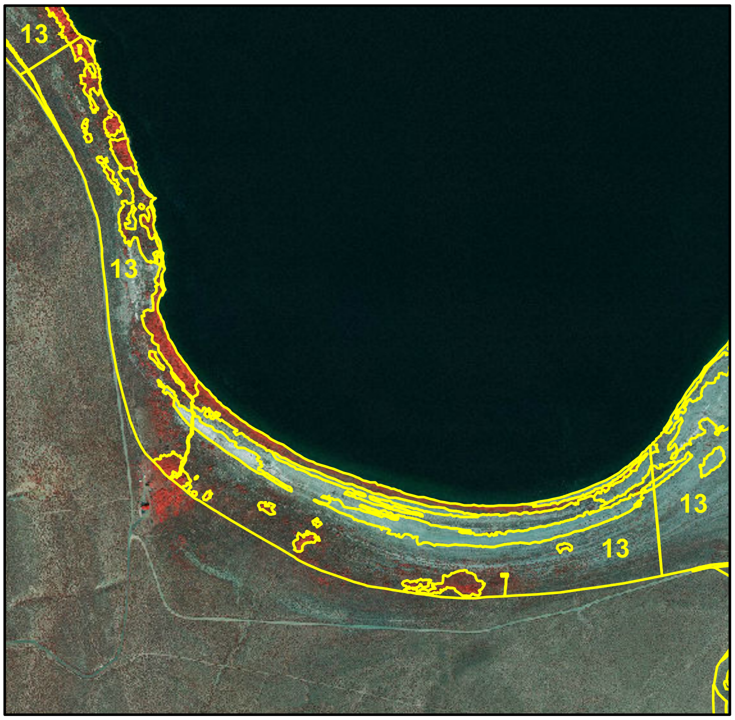
0 0.8

Miles

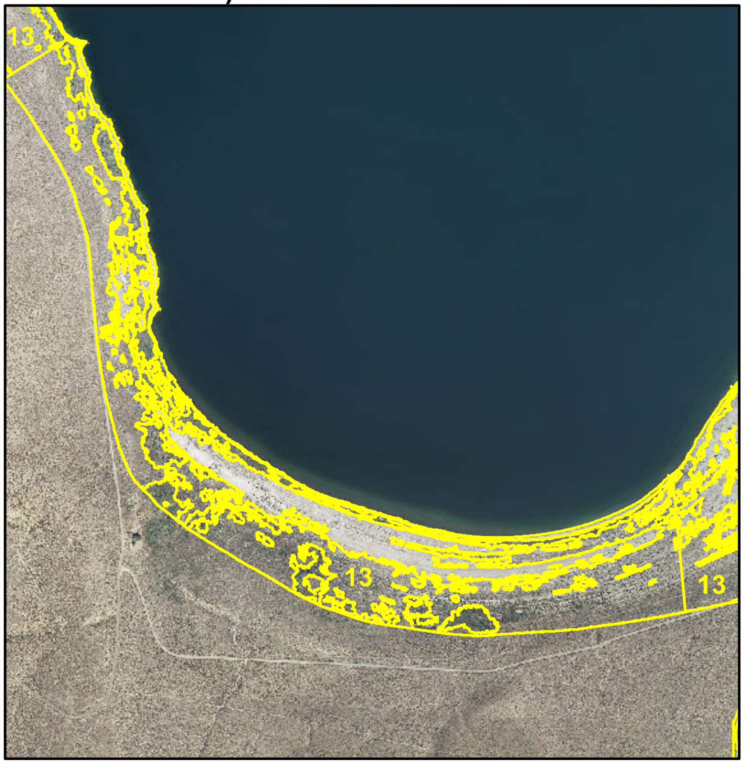


Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.

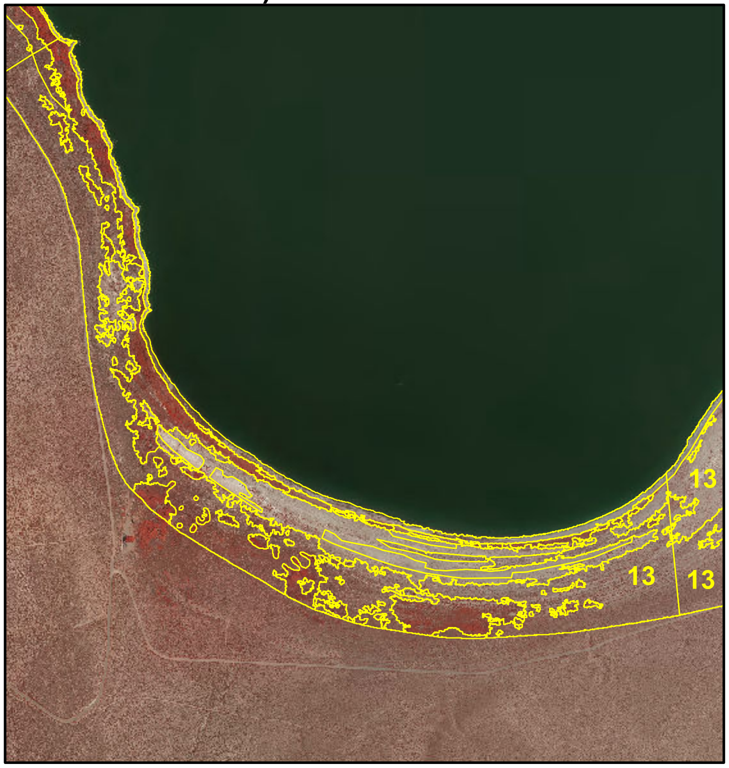
A) 1999 conditions.



B) 2005 conditions.



C) 2009 conditions.



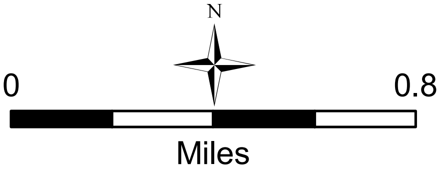
D) 2014 conditions.

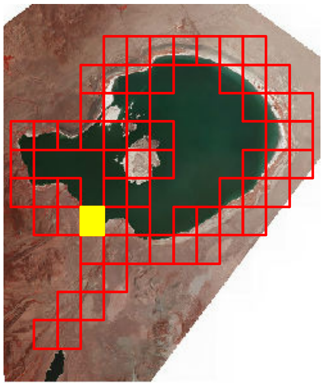
Mono Lake Landtype, Historical Conditions

Landtype Legend

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

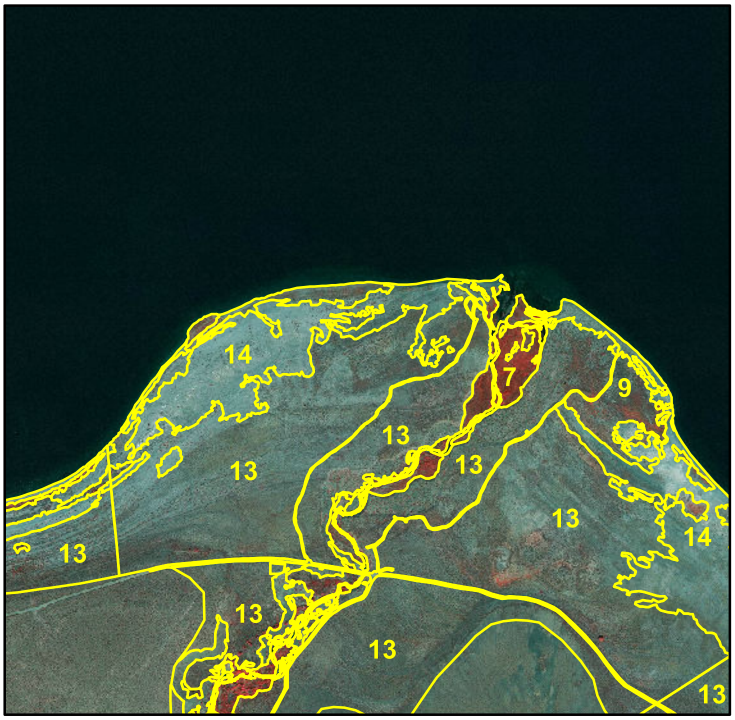
Map G4



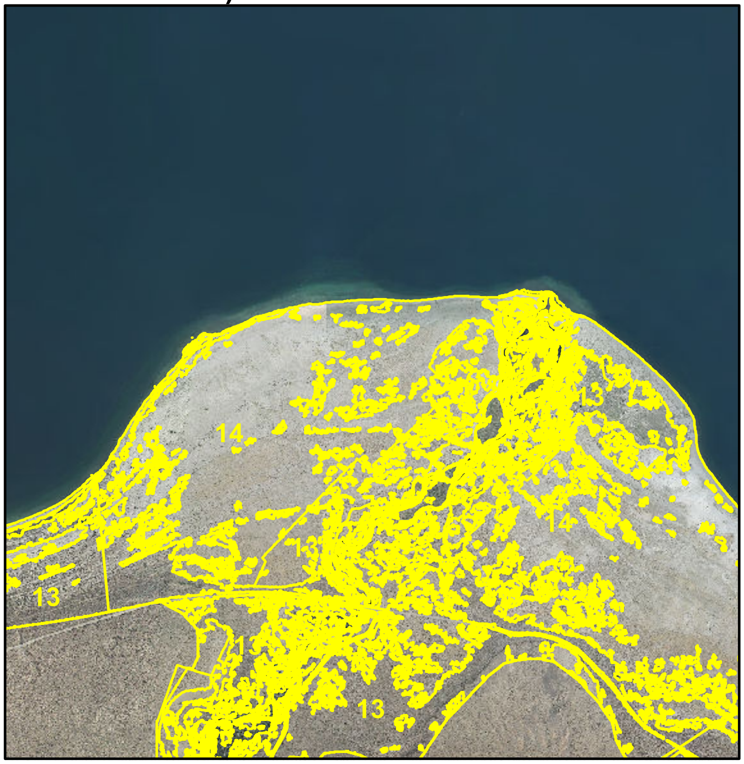


Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.

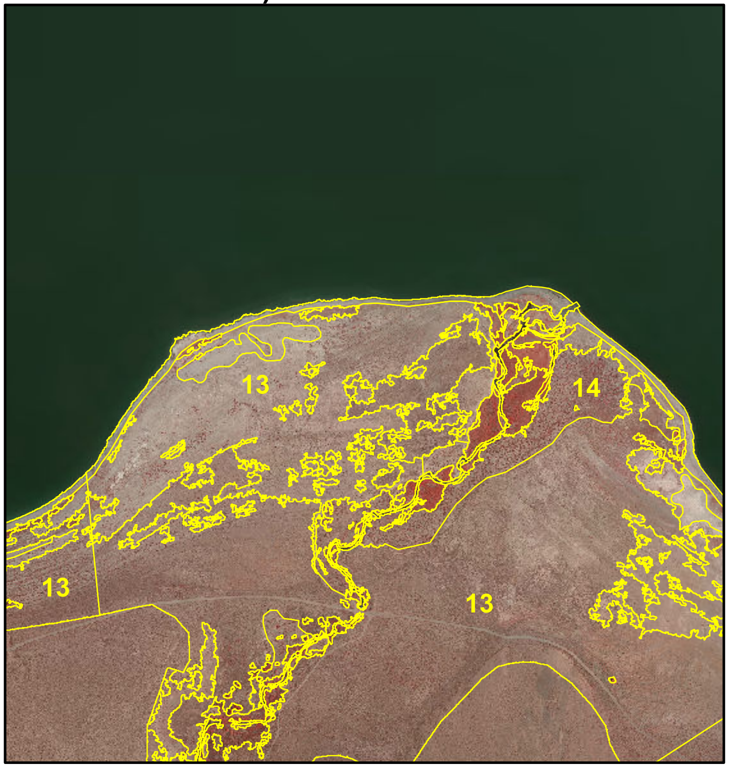
A) 1999 conditions.



B) 2005 conditions.



C) 2009 conditions.



D) 2014 conditions.

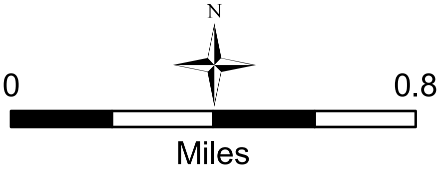
Mono Lake Landtype, Historical Conditions

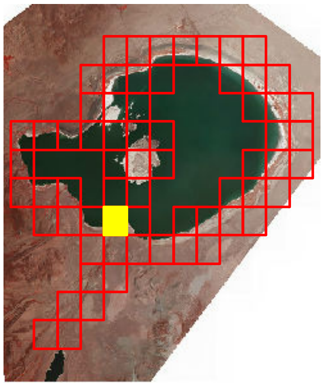
Landtype Legend

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow

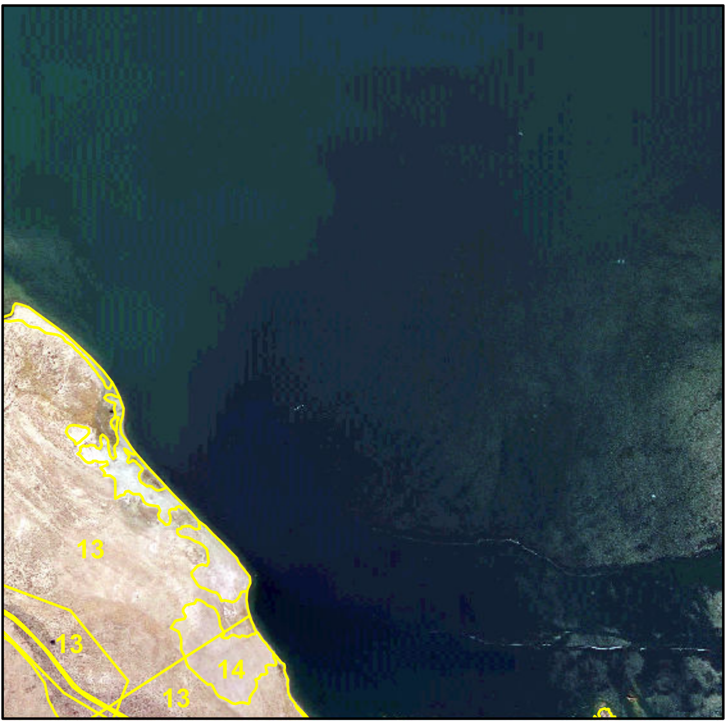
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map G5

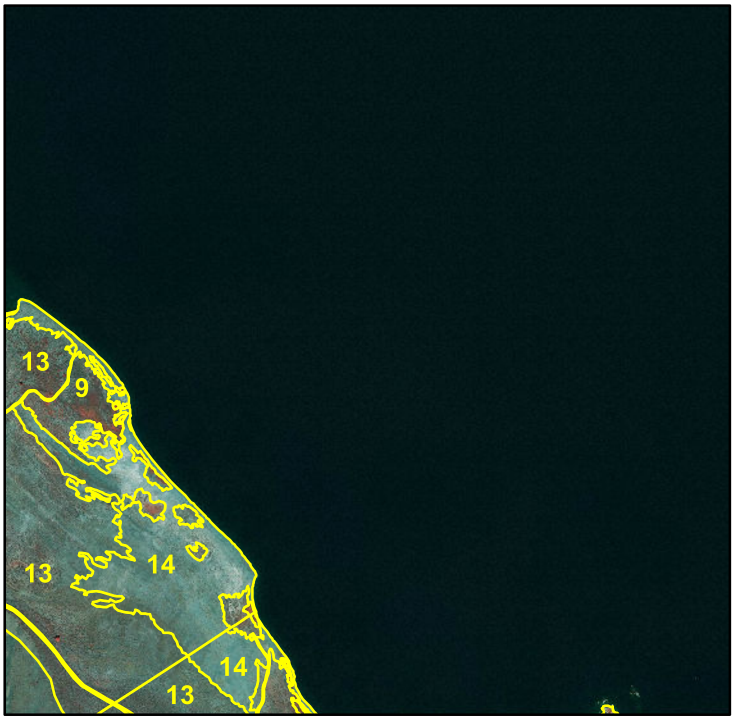




Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.

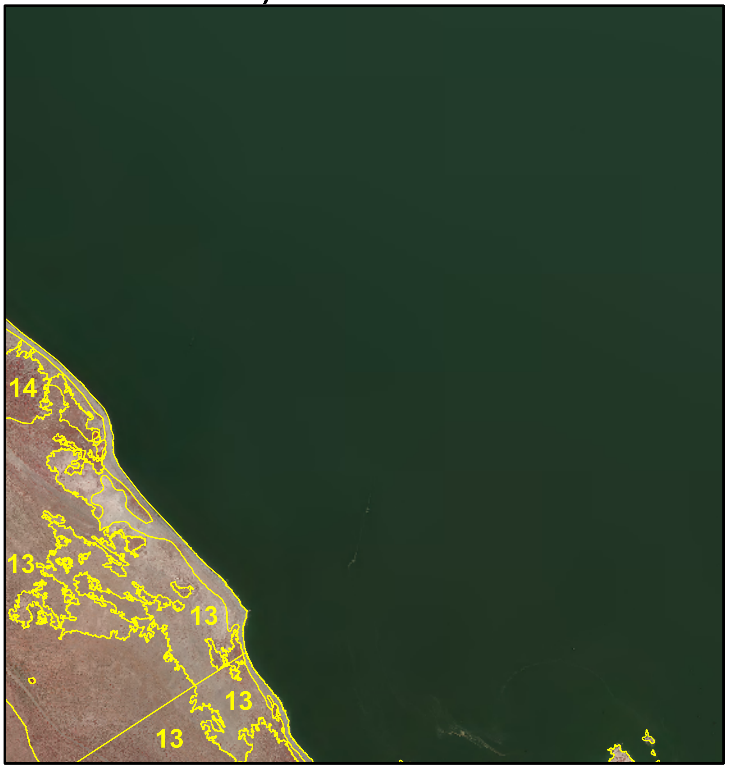


A) 1999 conditions.



B) 2005 conditions.

C) 2009 conditions.



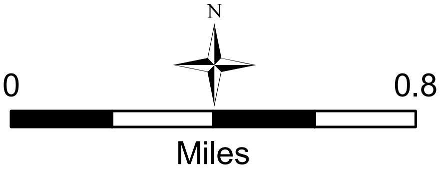
D) 2014 conditions.

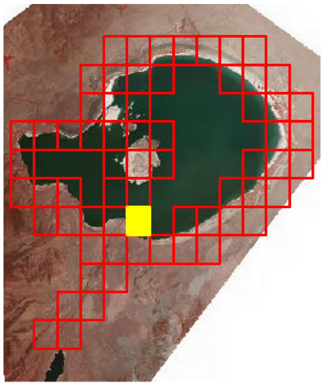
Mono Lake Landtype, Historical Conditions

Landtype Legend

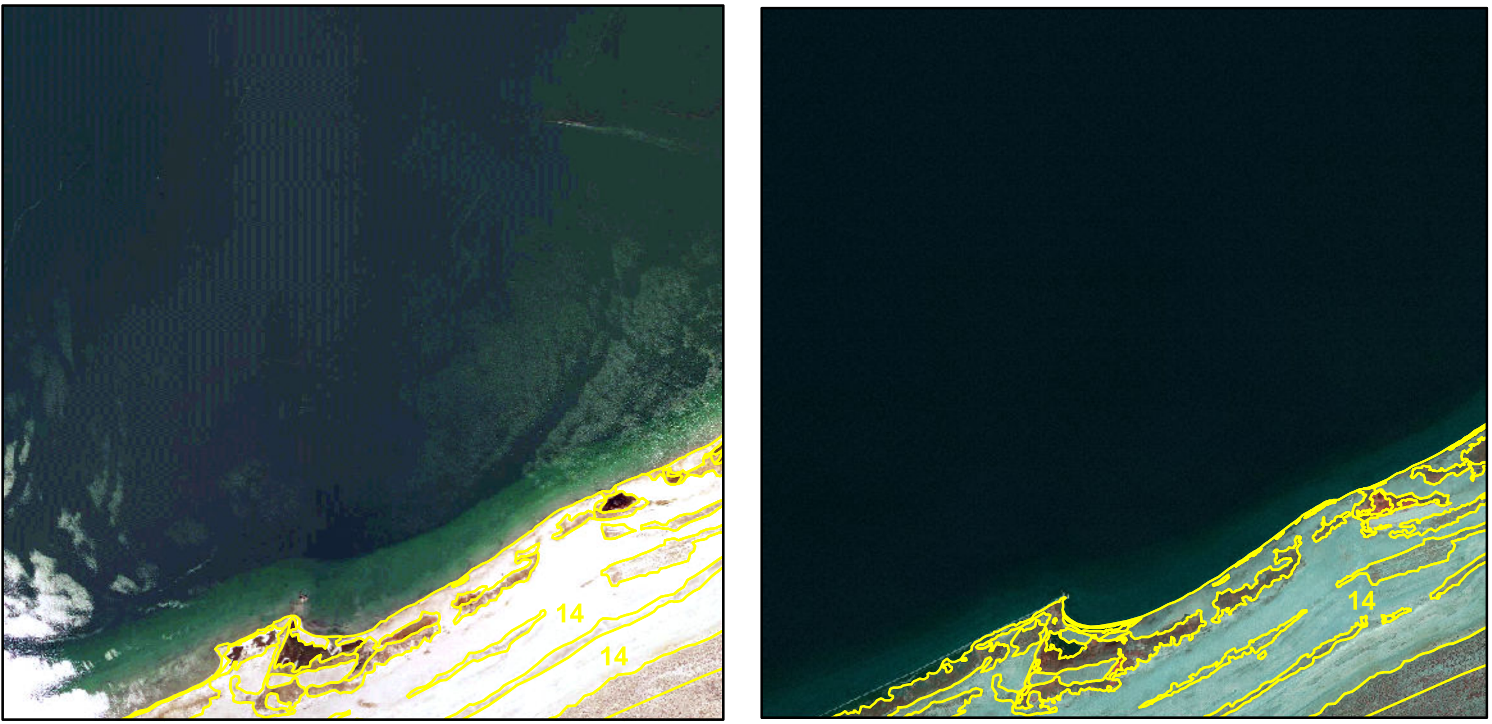
1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map G6

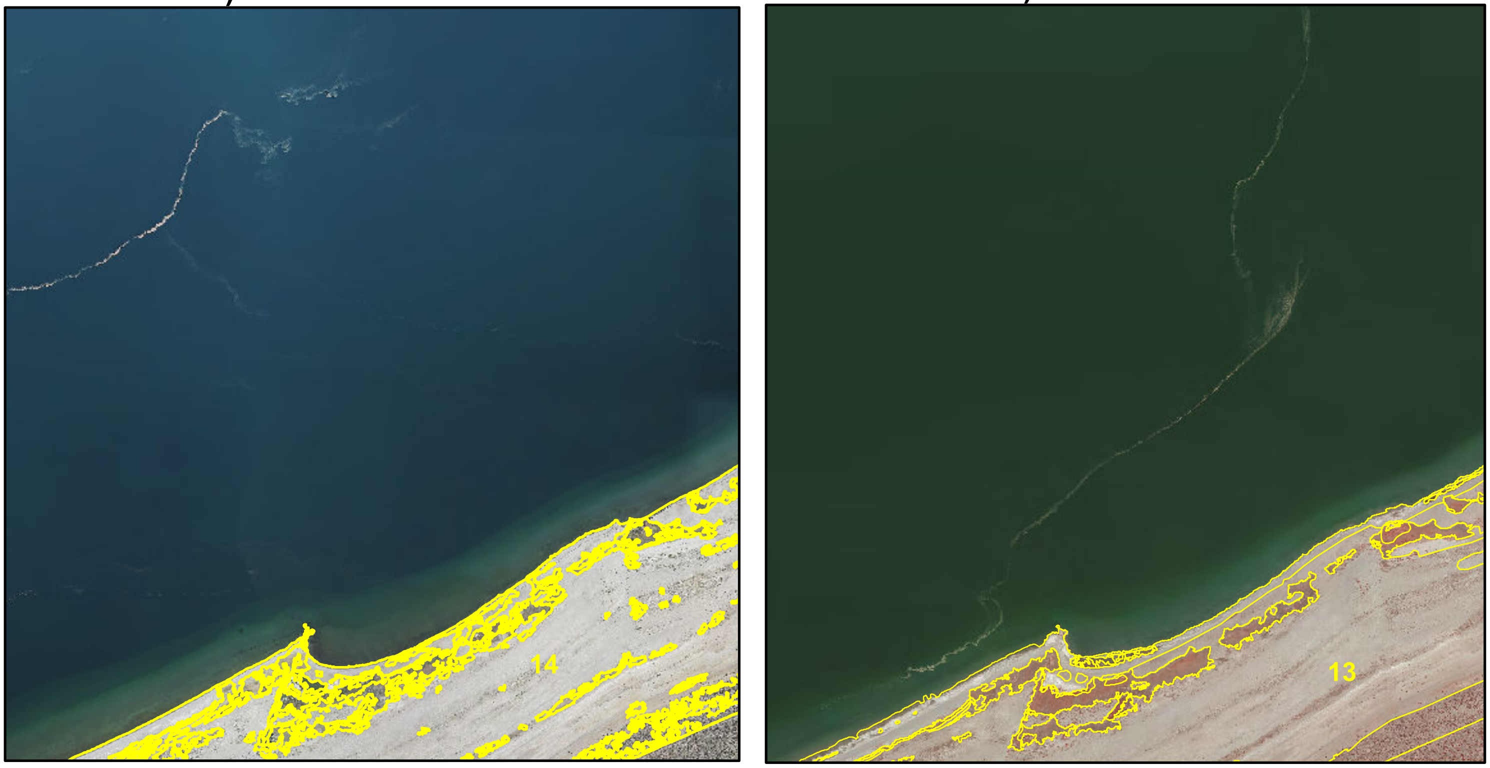




Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.



A) 1999 conditions. **B) 2005 conditions.**



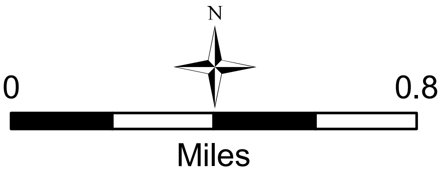
C) 2009 conditions. **D) 2014 conditions.**

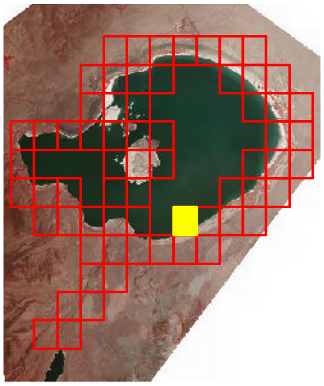
Mono Lake Landtype, Historical Conditions

Landtype Legend

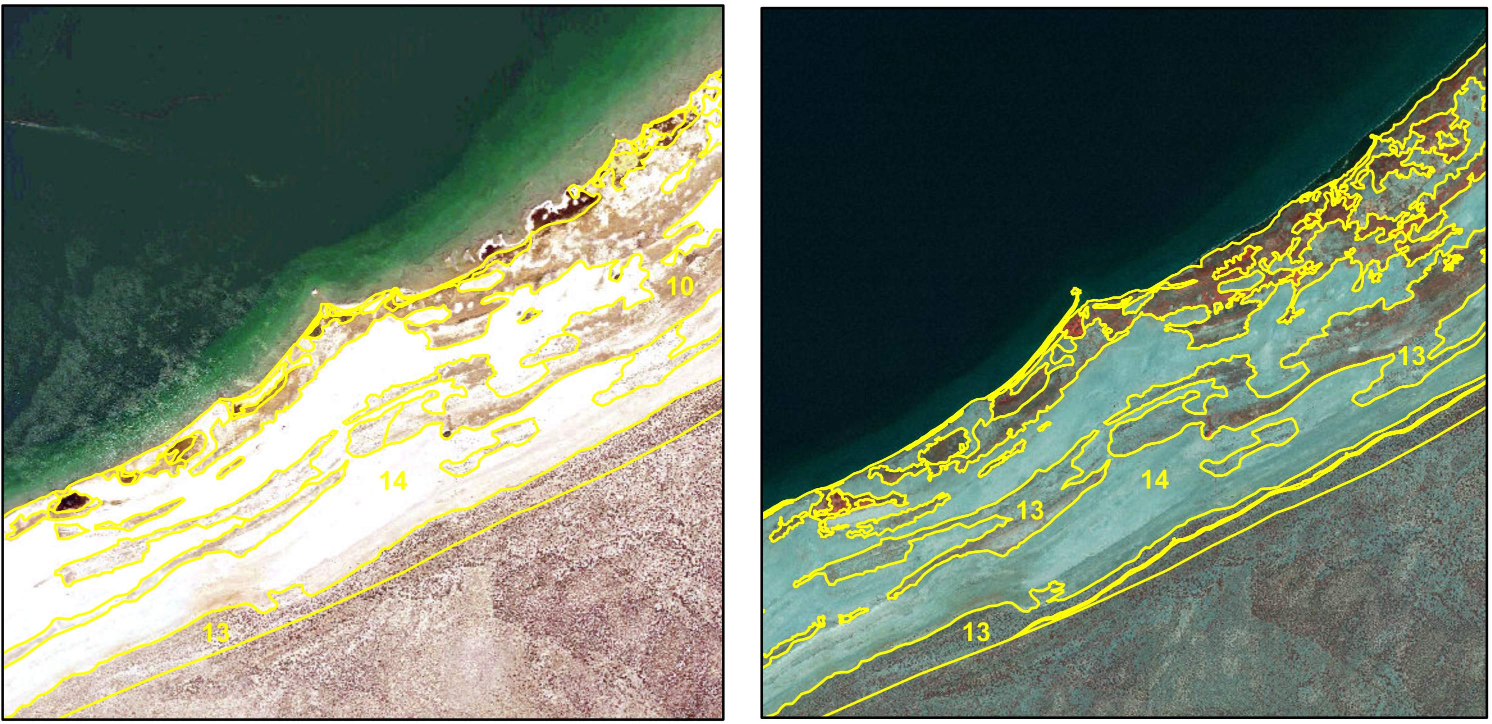
1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map G8



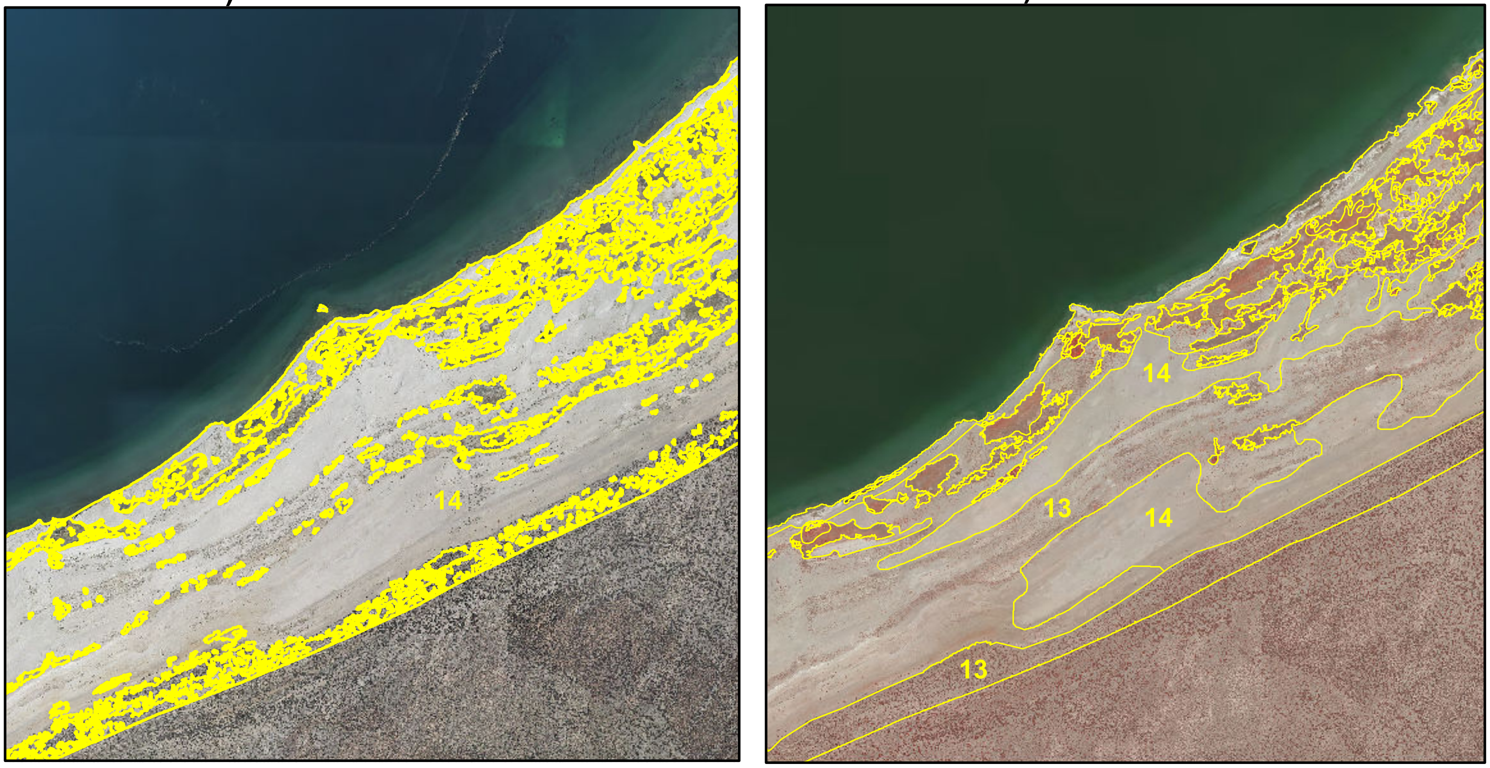


Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.



A) 1999 conditions.

B) 2005 conditions.



C) 2009 conditions.

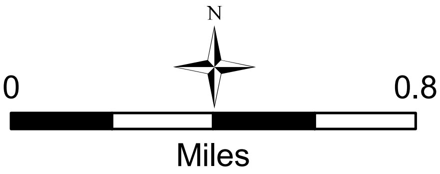
D) 2014 conditions.

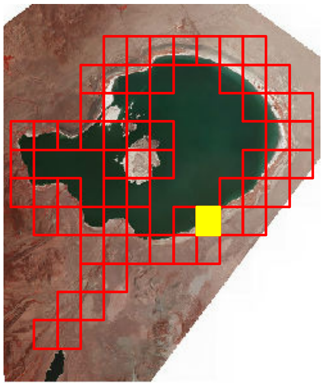
Mono Lake Landtype, Historical Conditions

Landtype Legend

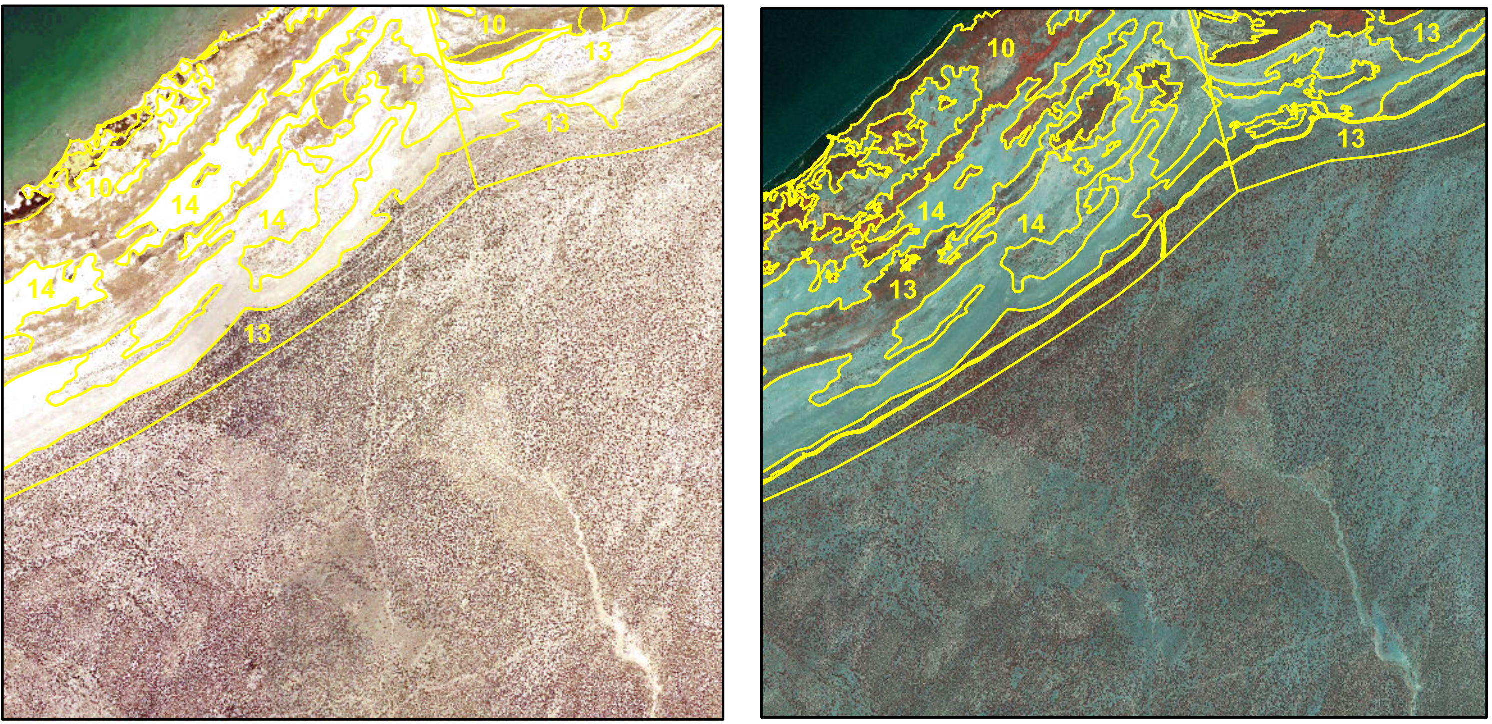
1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map G9



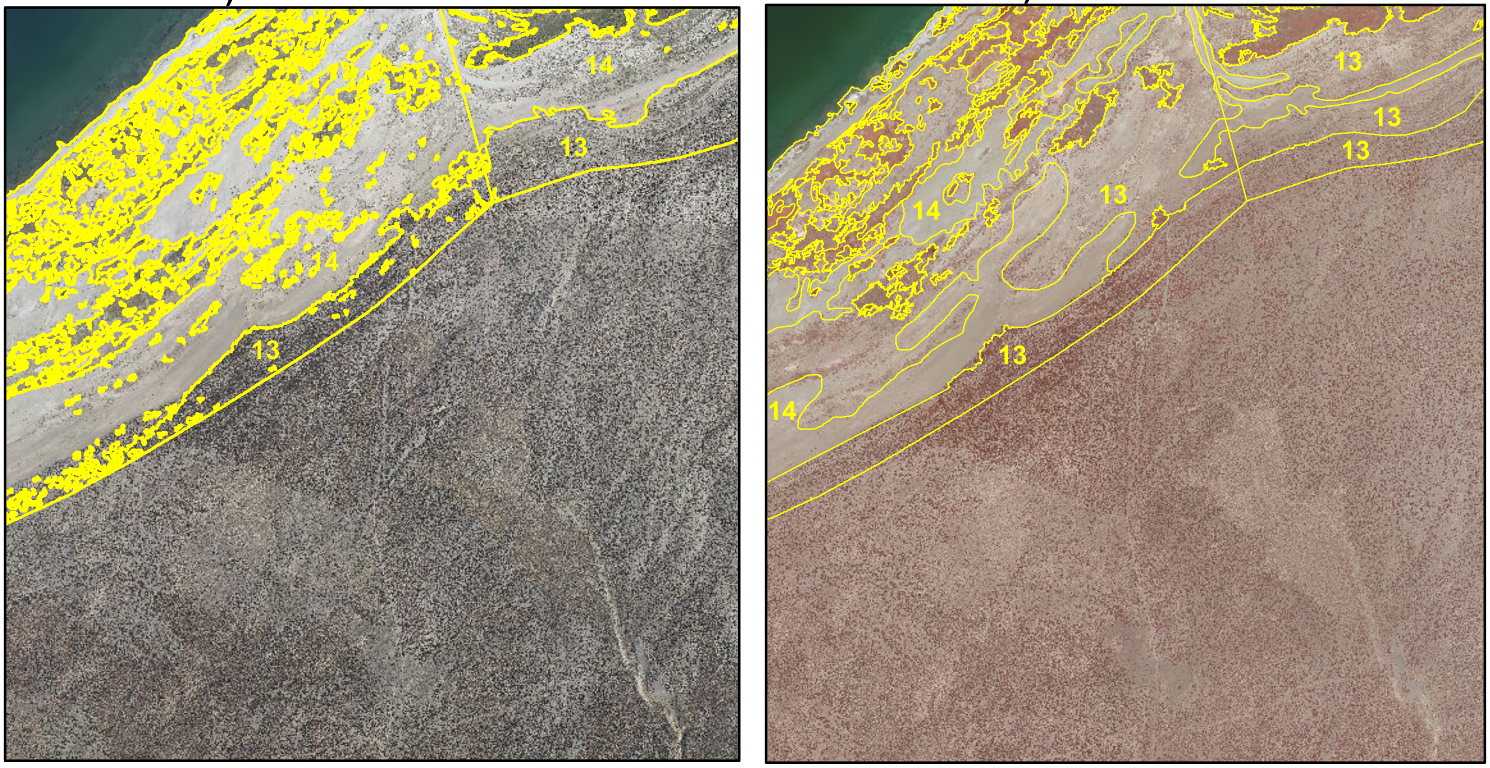


Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.



A) 1999 conditions.

B) 2005 conditions.



C) 2009 conditions.

D) 2014 conditions.

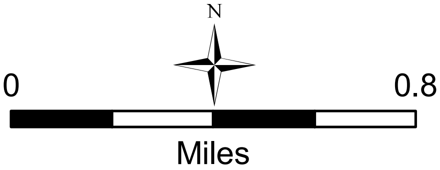
Mono Lake Landtype, Historical Conditions

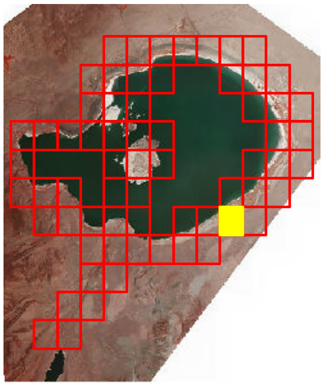
Landtype Legend

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow

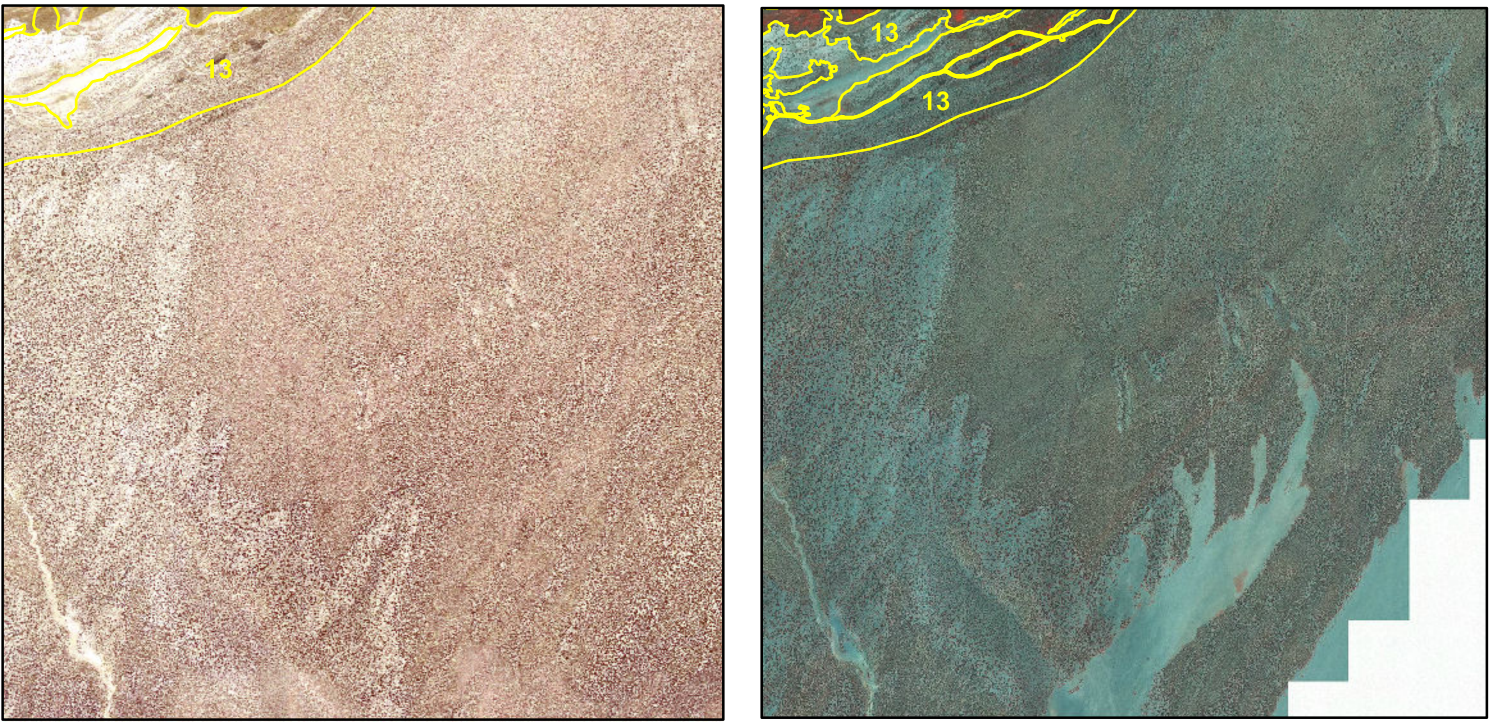
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map G10



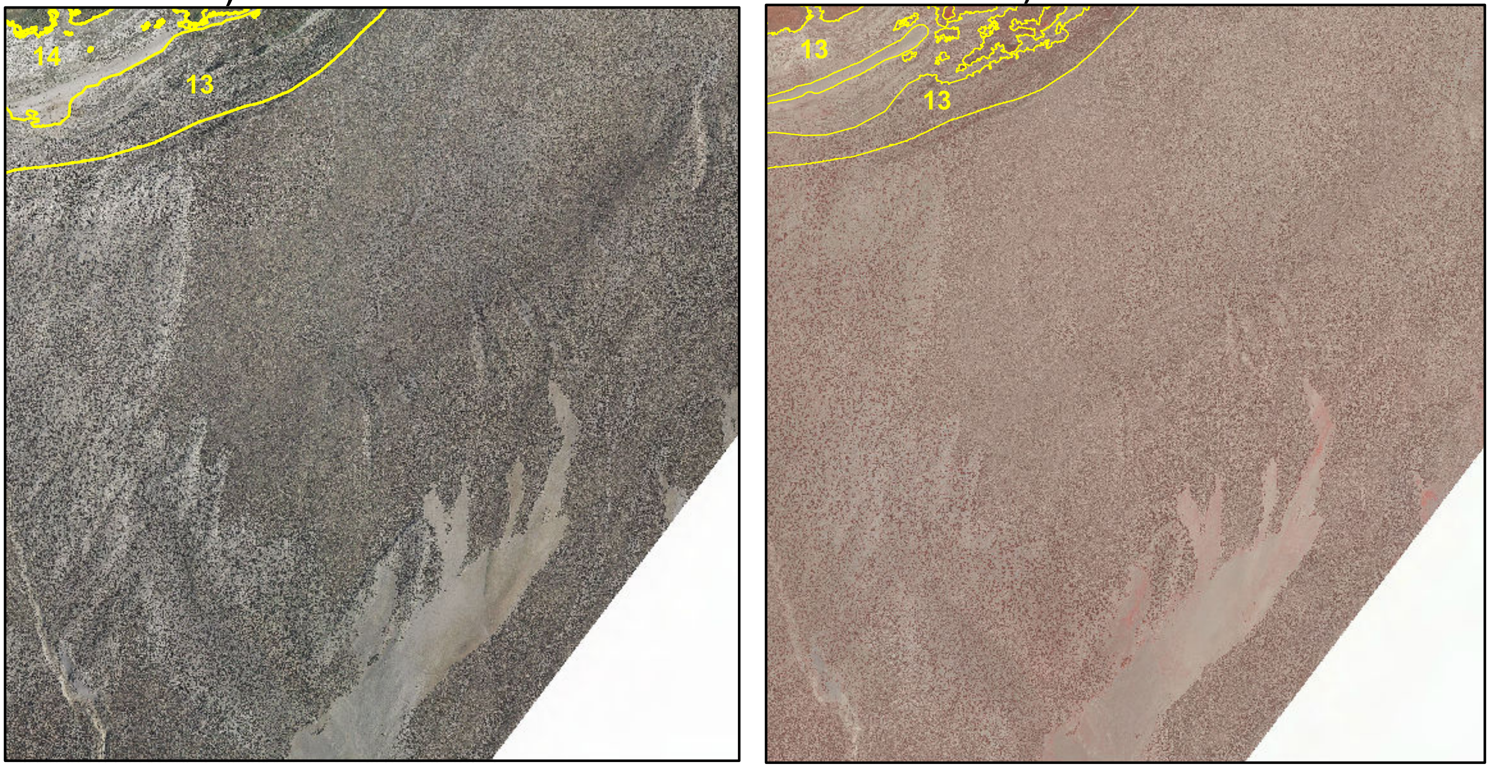


Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.



A) 1999 conditions.

B) 2005 conditions.



C) 2009 conditions.

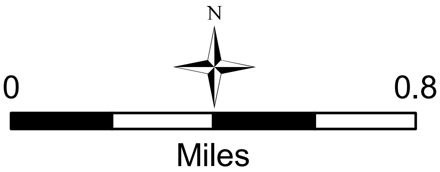
D) 2014 conditions.

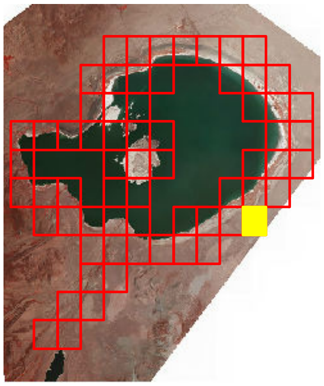
Mono Lake Landtype, Historical Conditions

Landtype Legend

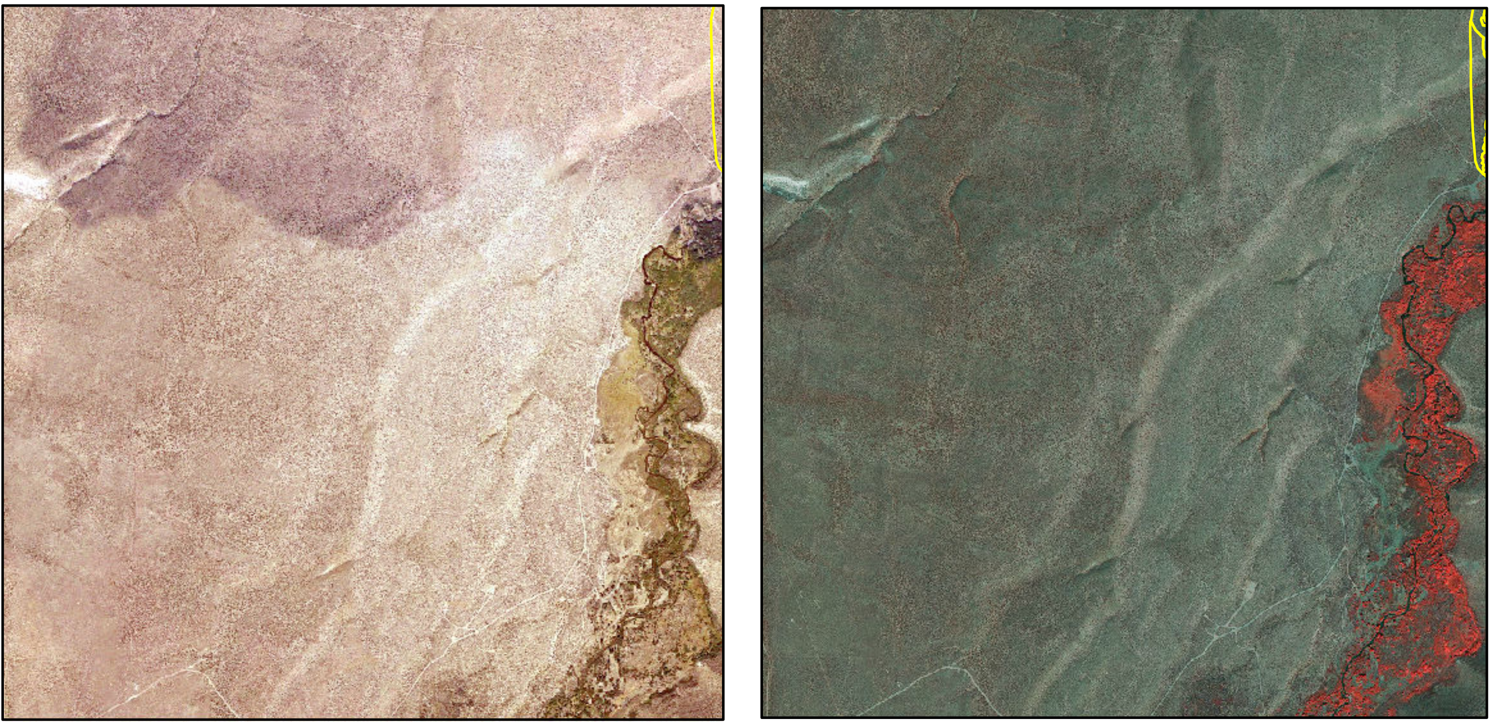
1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map G11



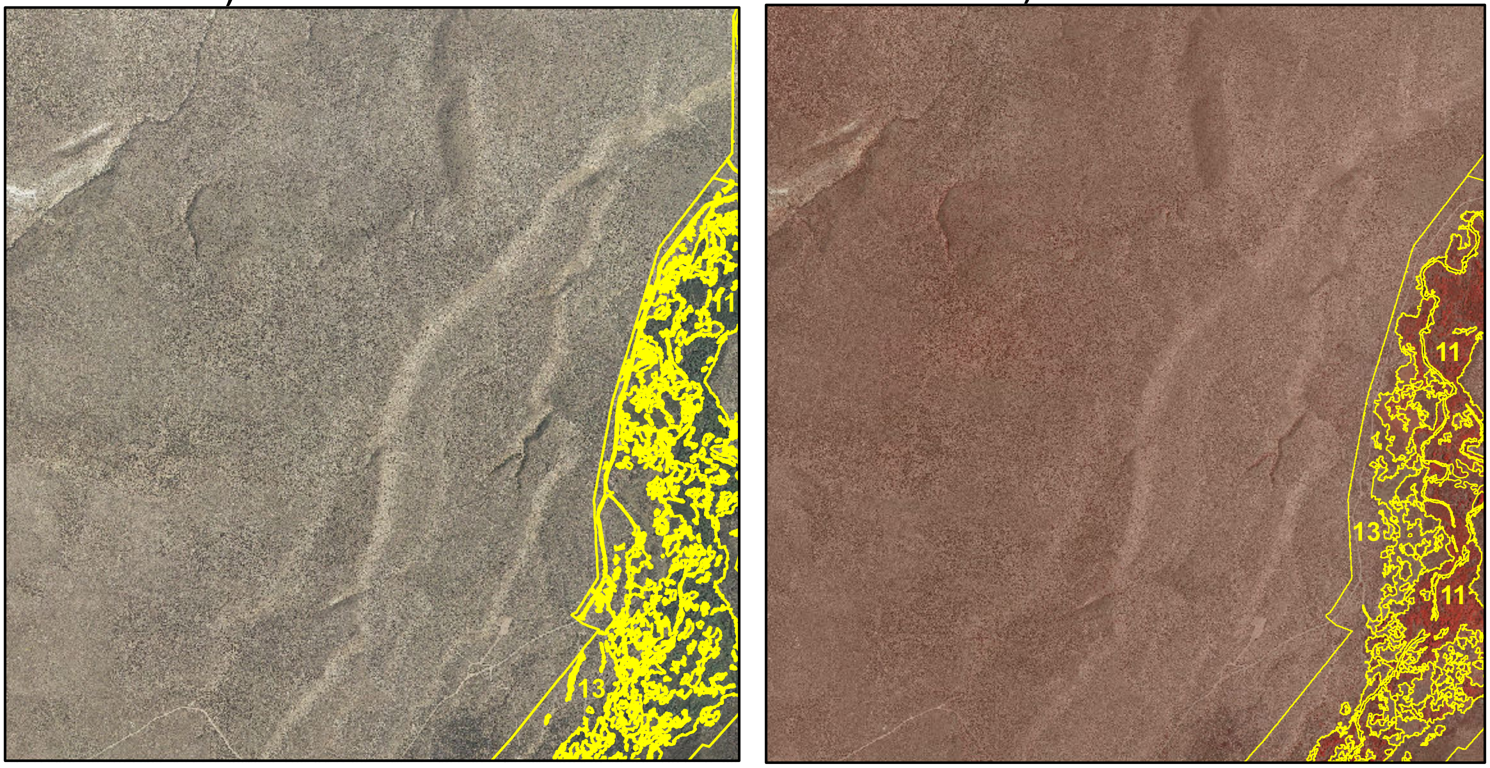


Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.



A) 1999 conditions.

B) 2005 conditions.



C) 2009 conditions.

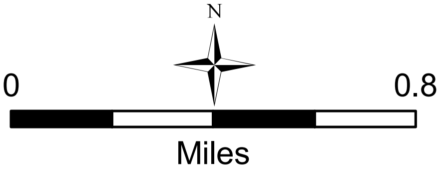
D) 2014 conditions.

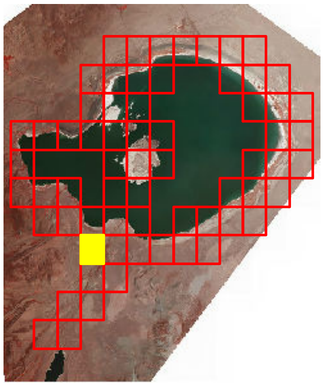
Mono Lake Landtype, Historical Conditions

Landtype Legend

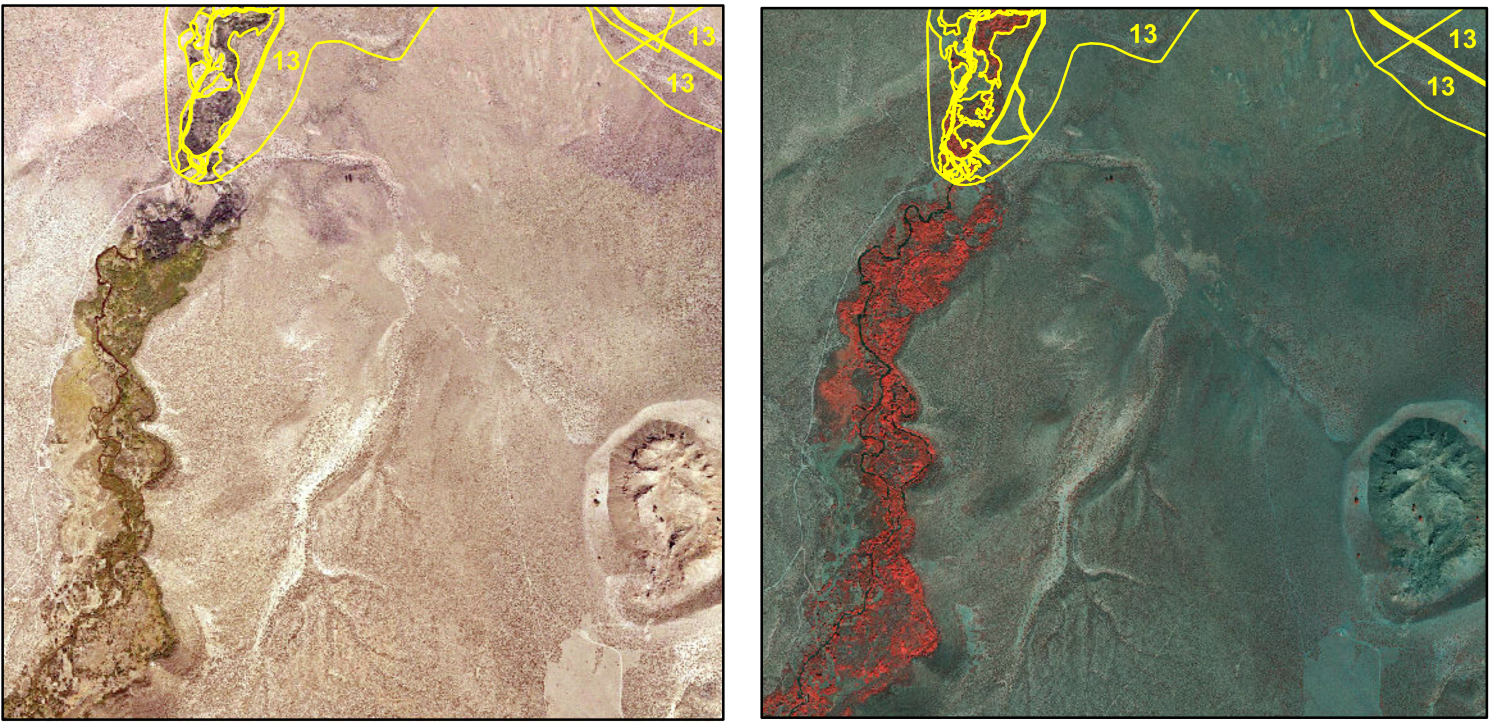
1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map H4



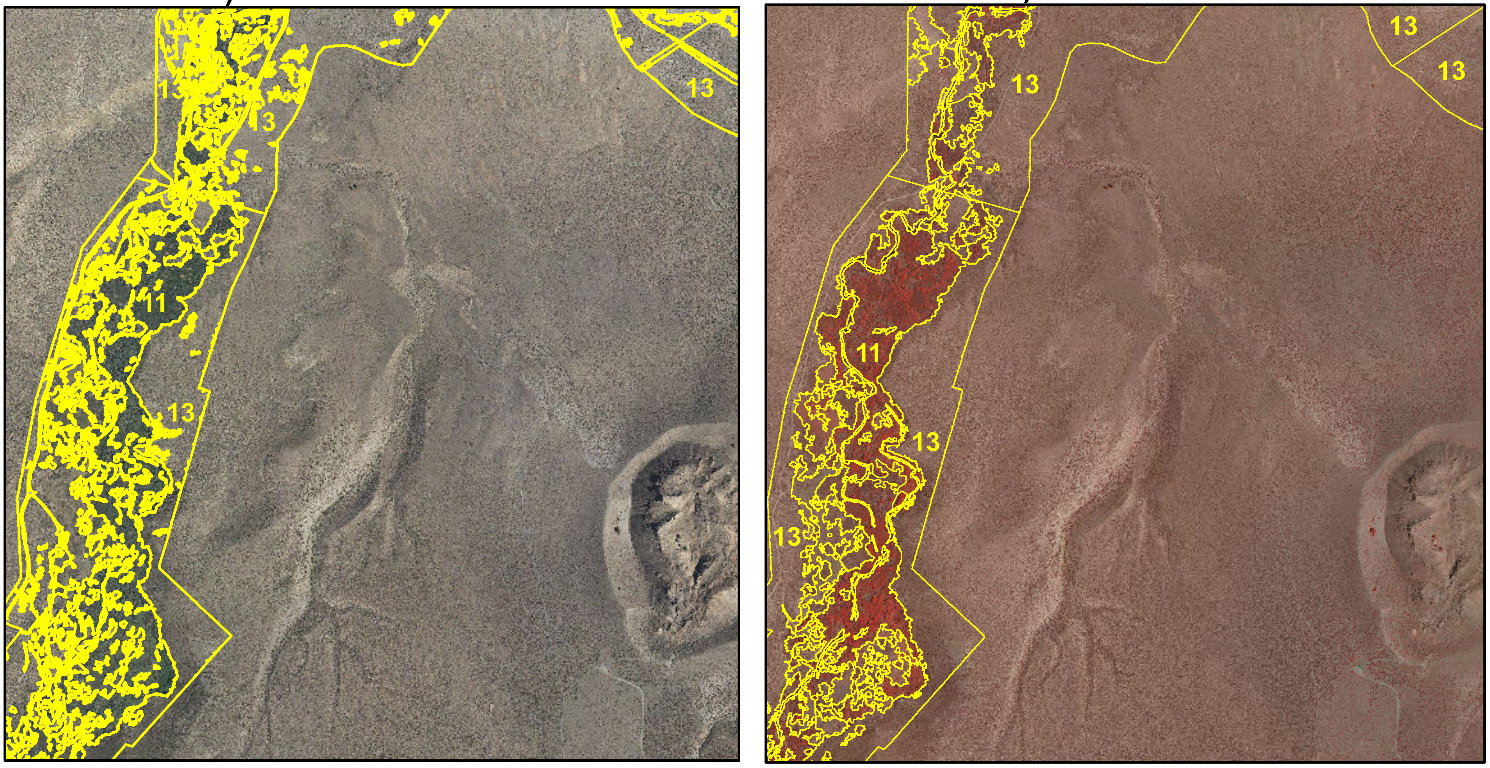


Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.



A) 1999 conditions.

B) 2005 conditions.



C) 2009 conditions.

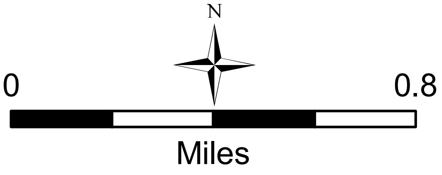
D) 2014 conditions.

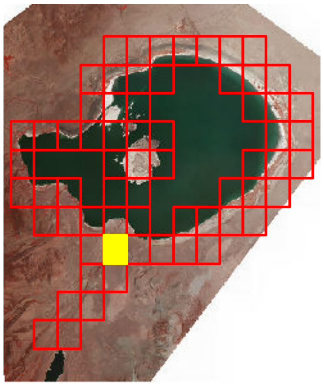
Mono Lake Landtype, Historical Conditions

Landtype Legend

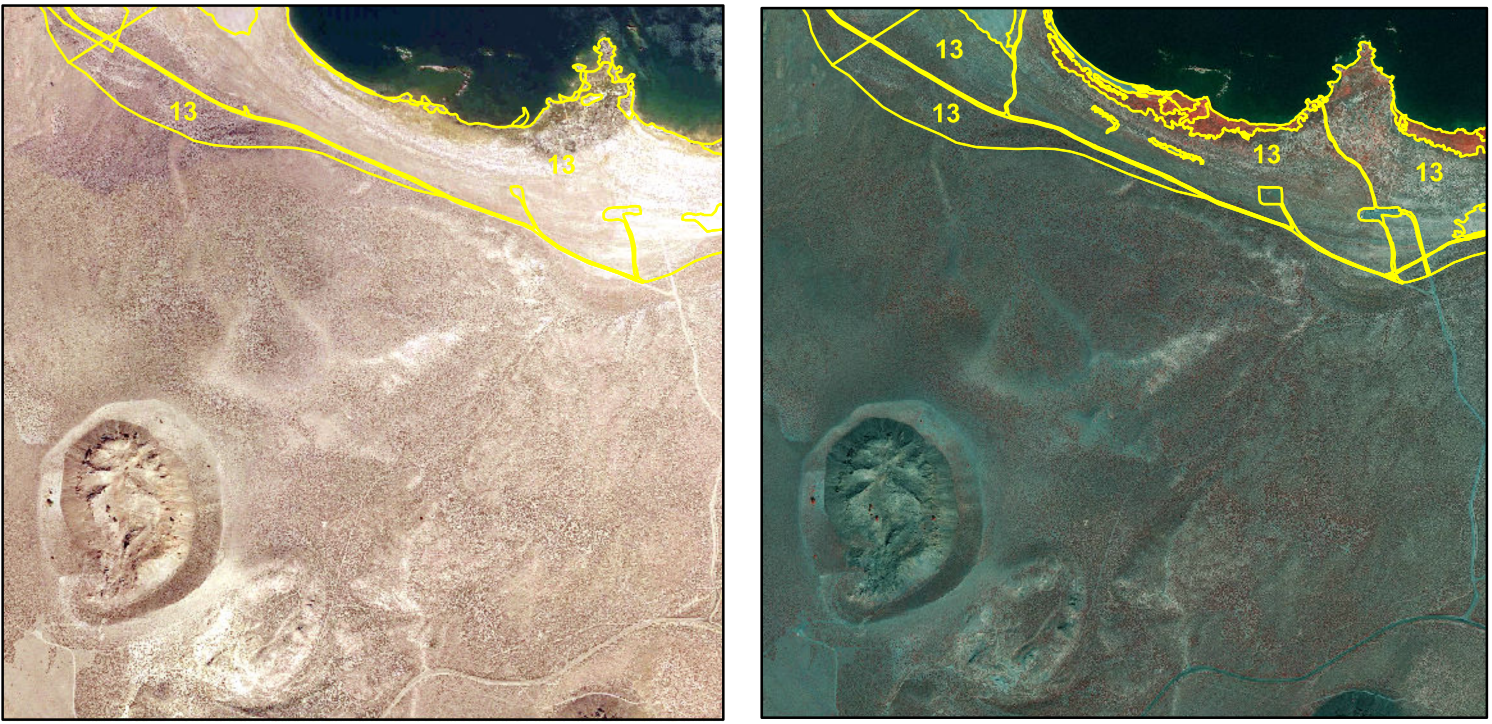
1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map H5



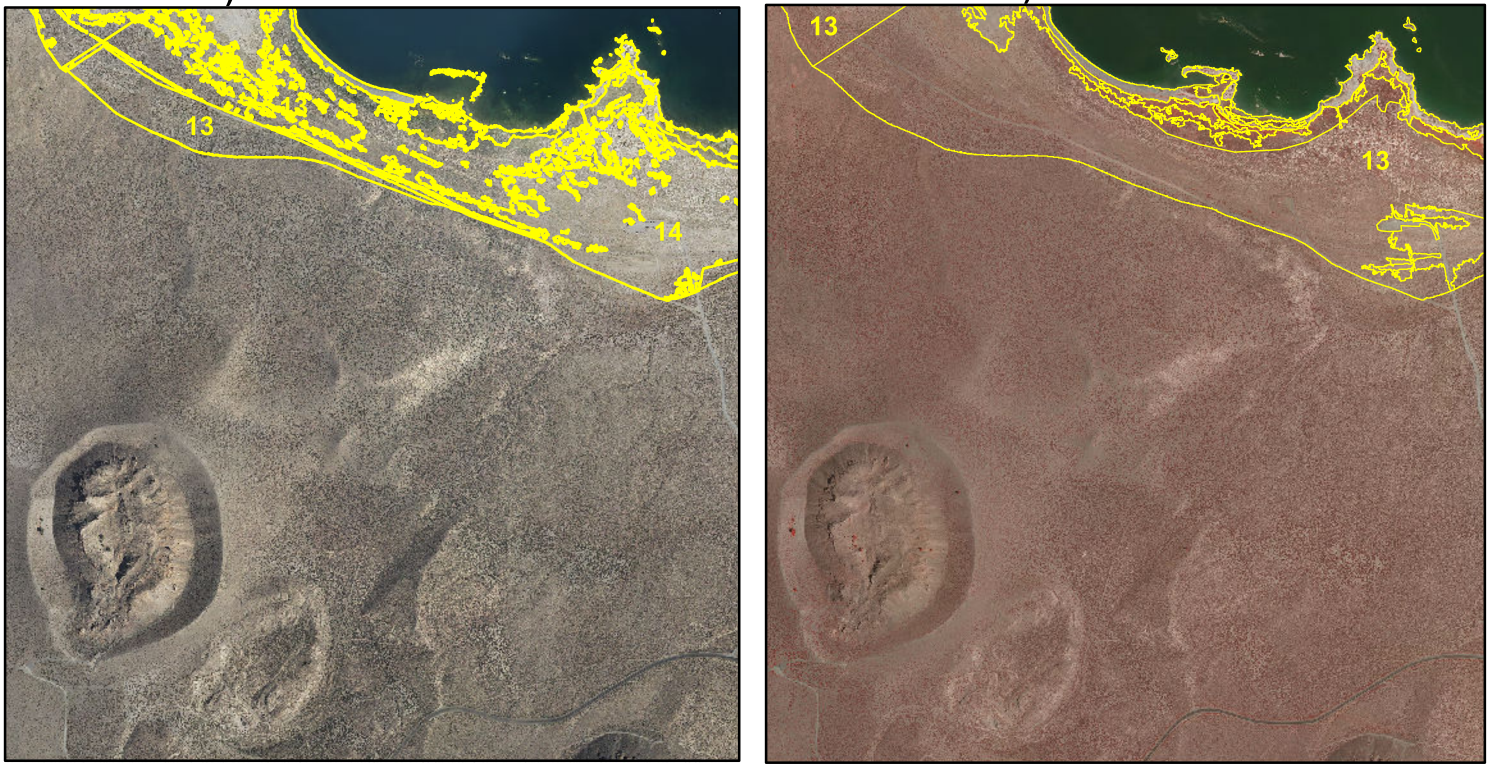


Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.



A) 1999 conditions.

B) 2005 conditions.



C) 2009 conditions.

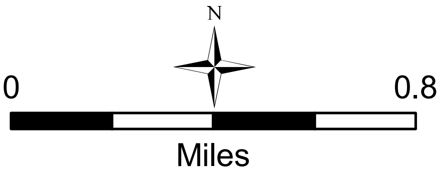
D) 2014 conditions.

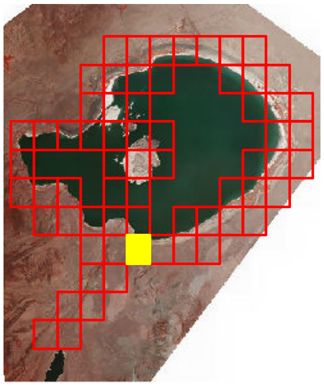
Mono Lake Landtype, Historical Conditions

Landtype Legend

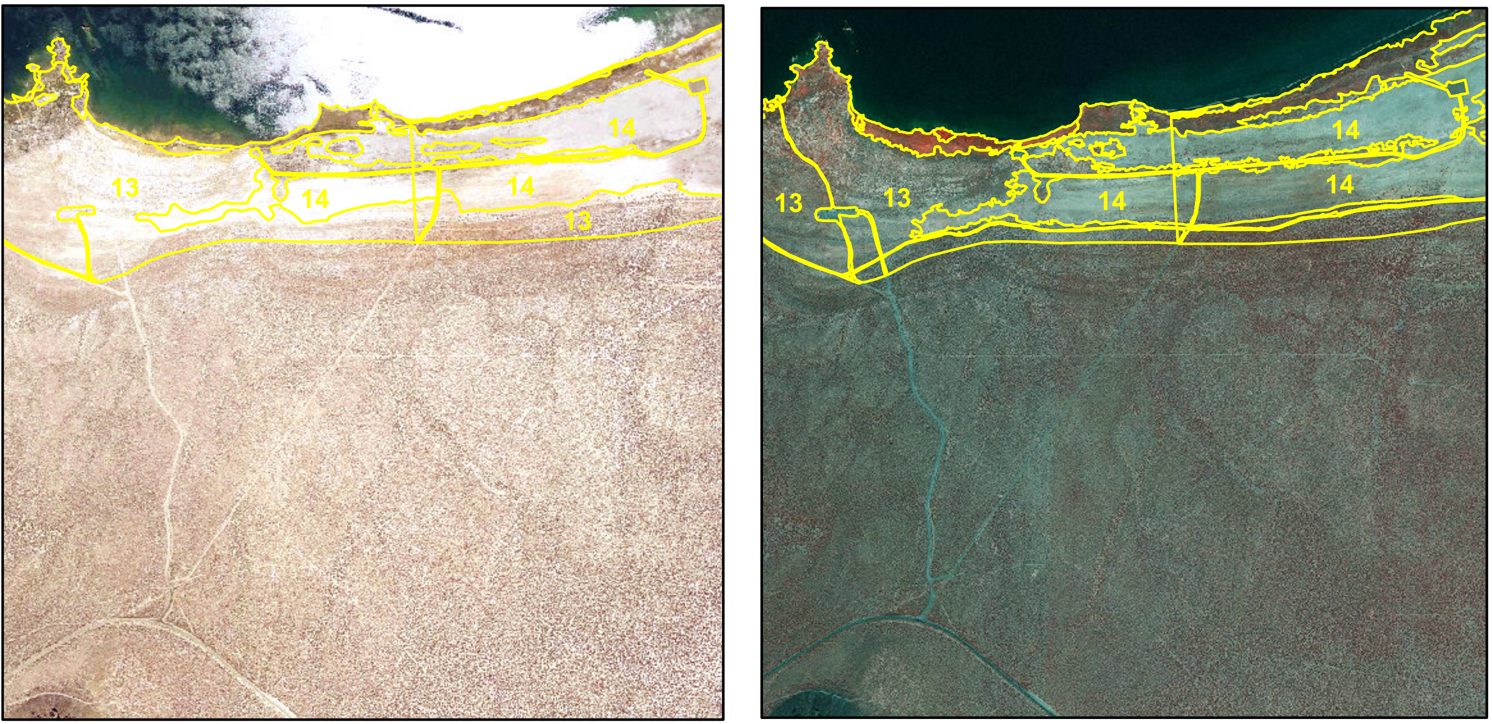
1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map H6



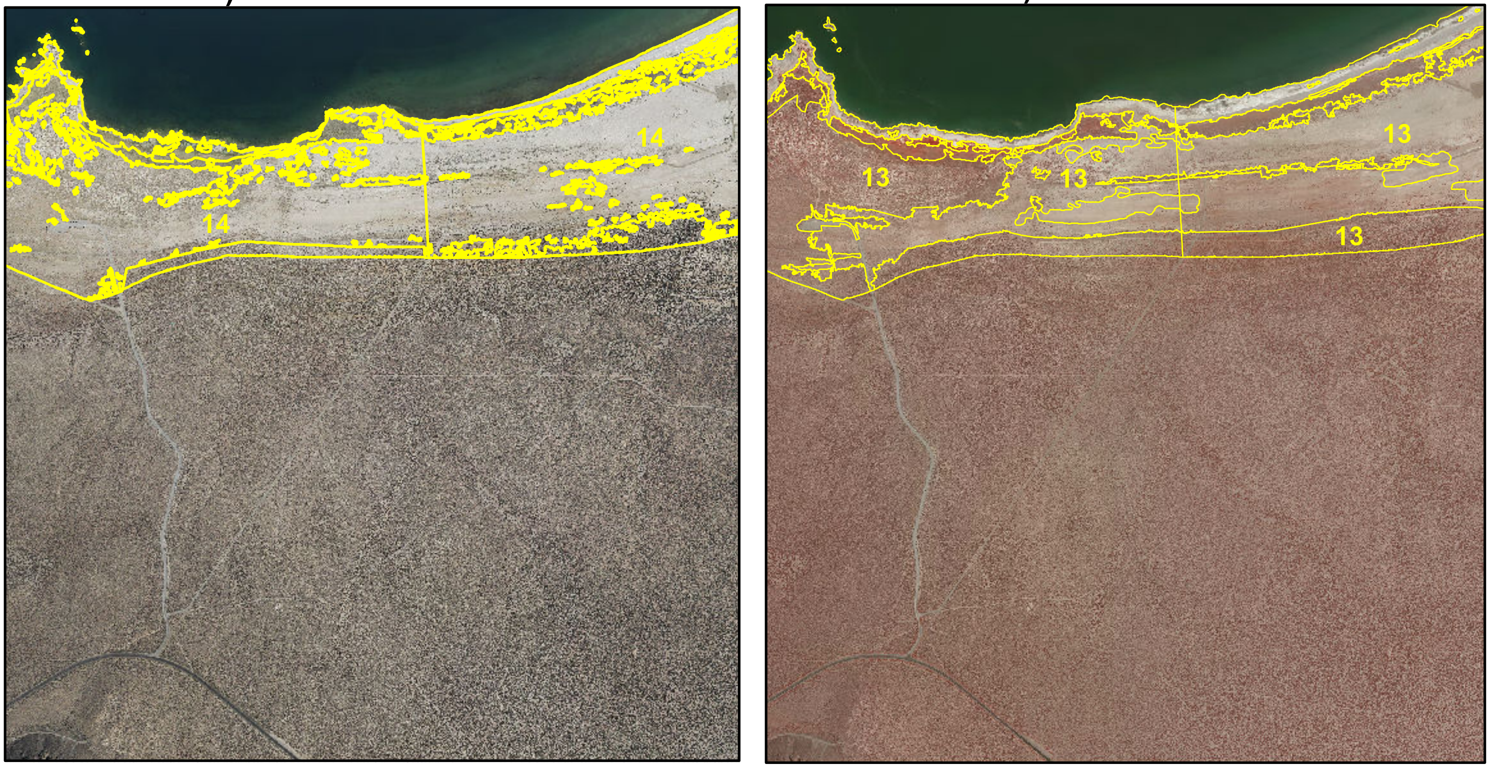


Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.



A) 1999 conditions.

B) 2005 conditions.



C) 2009 conditions.

D) 2014 conditions.

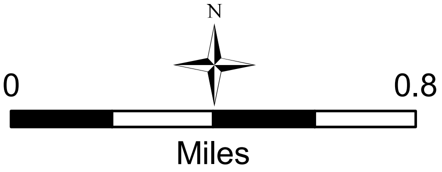
Mono Lake Landtype, Historical Conditions

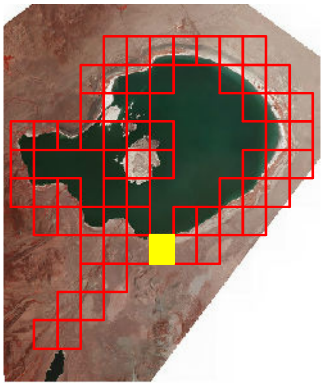
Landtype Legend

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow

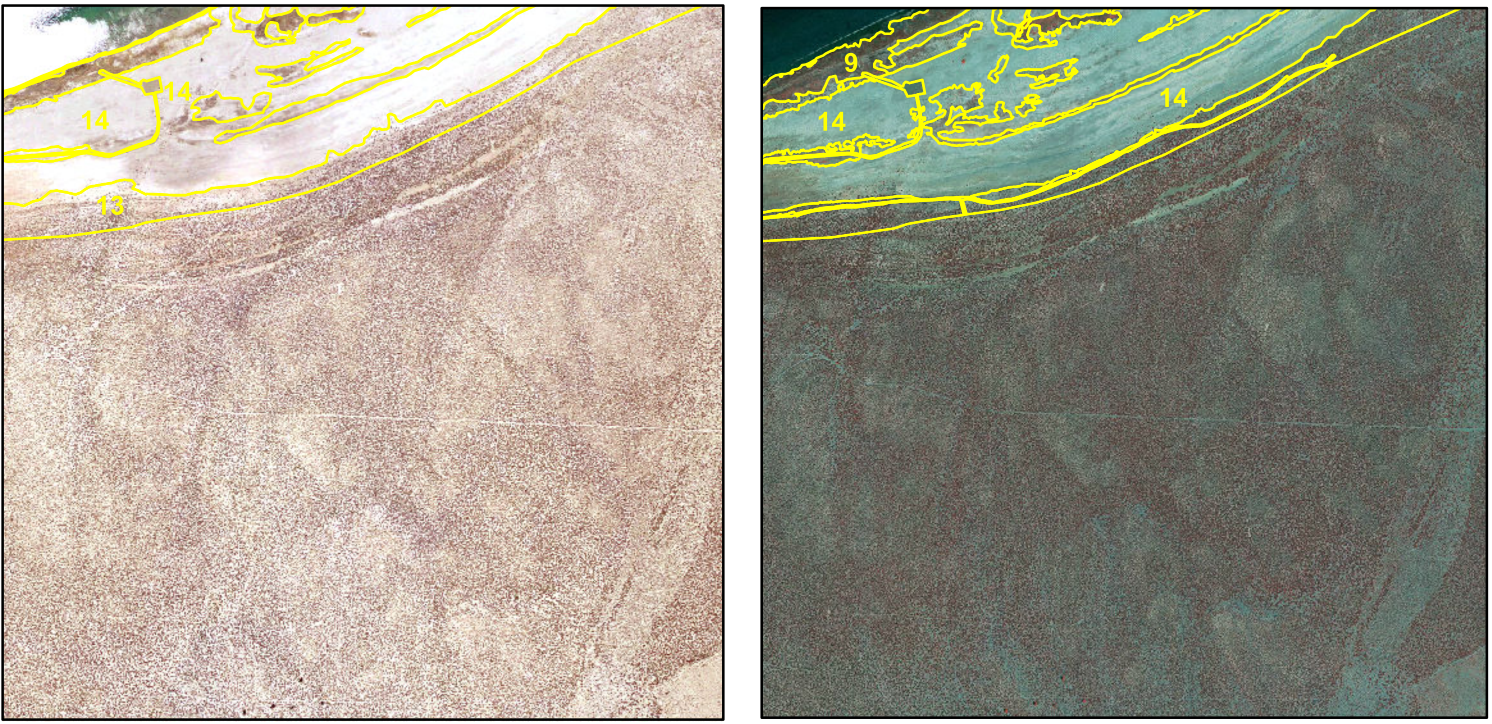
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map H7



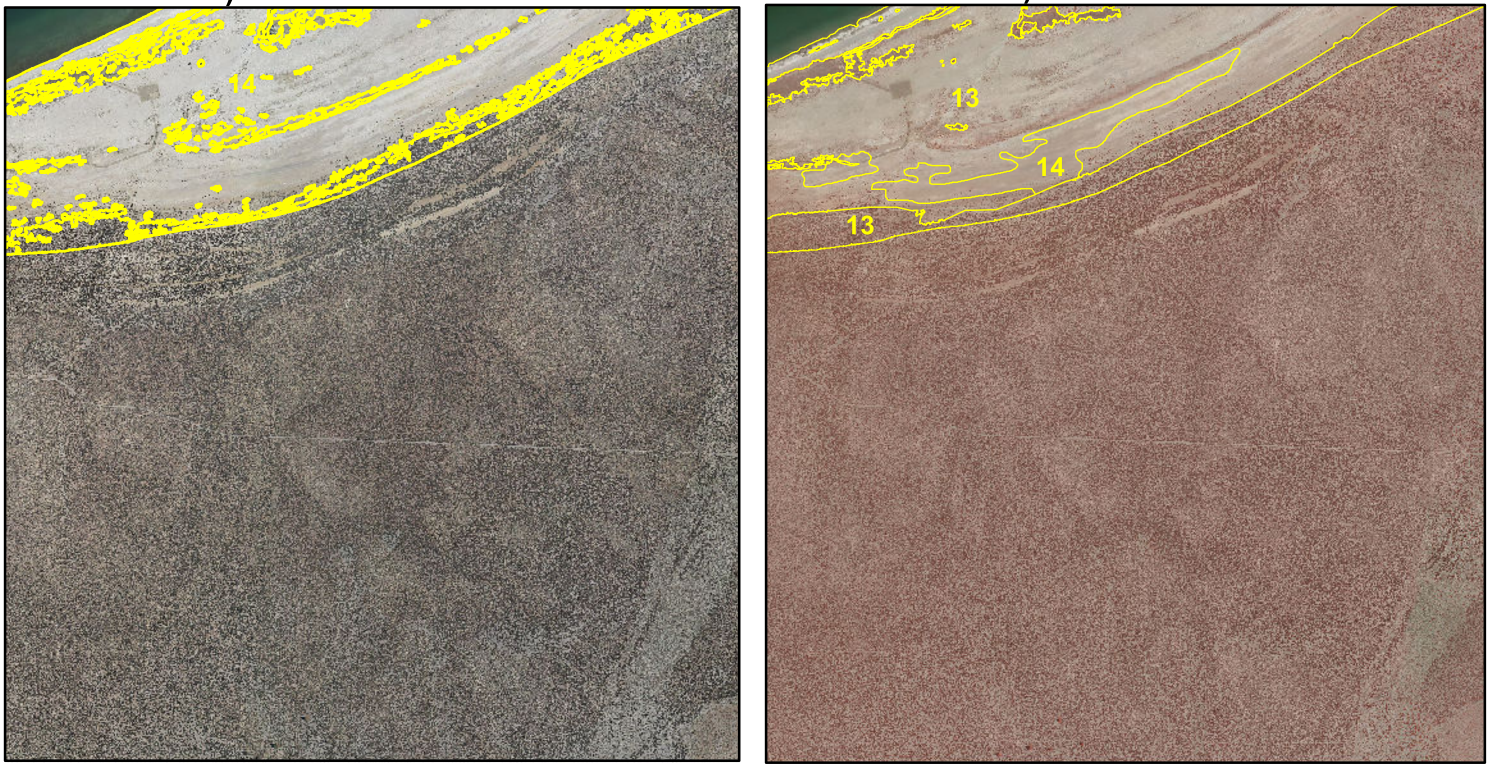


Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.



A) 1999 conditions.

B) 2005 conditions.



C) 2009 conditions.

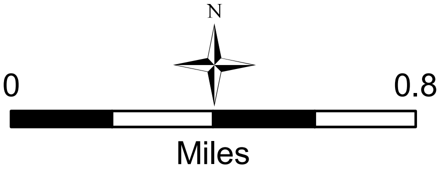
D) 2014 conditions.

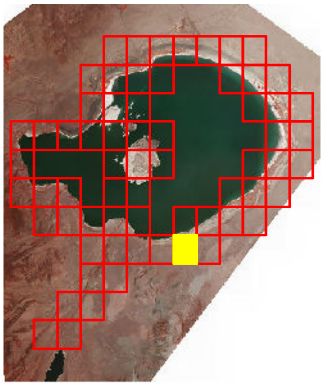
Mono Lake Landtype, Historical Conditions

Landtype Legend

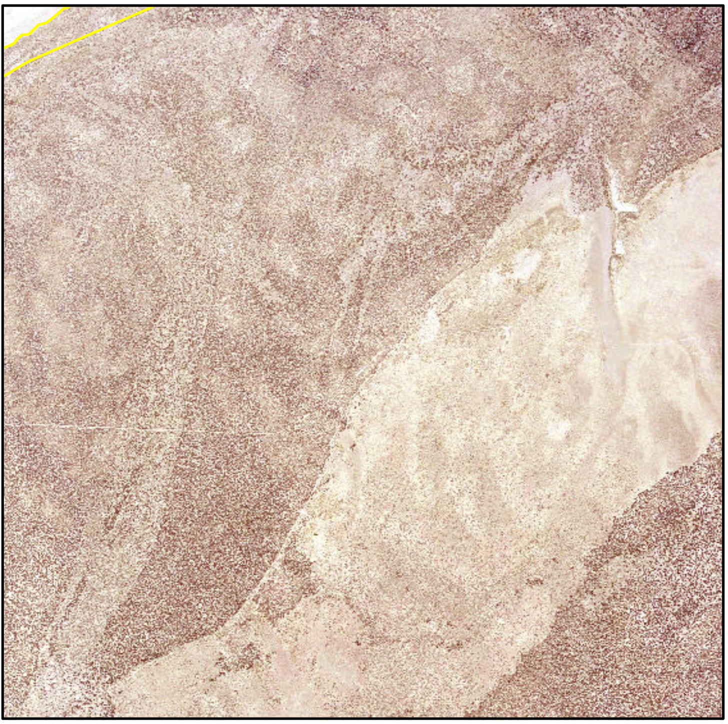
1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map H8

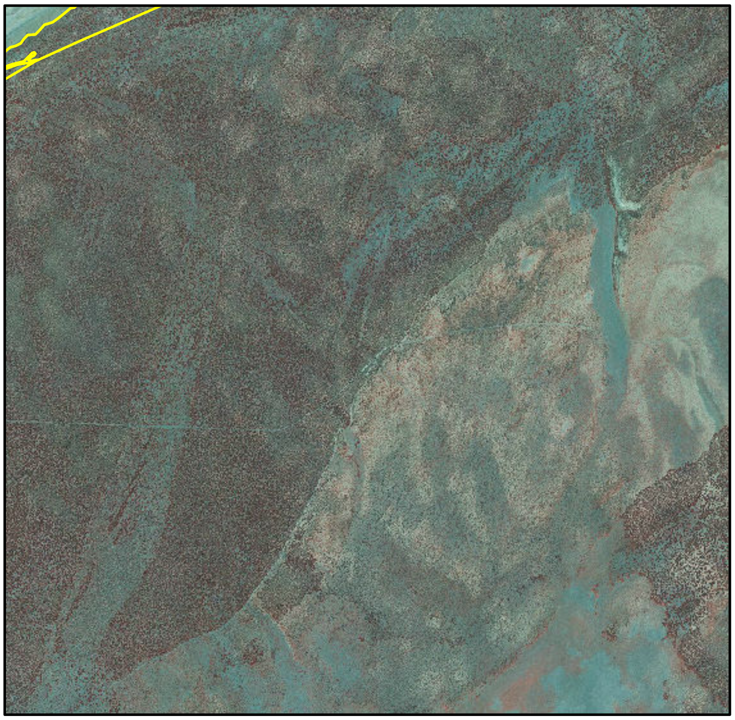




Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.



A) 1999 conditions.



B) 2005 conditions.

C) 2009 conditions.

D) 2014 conditions.

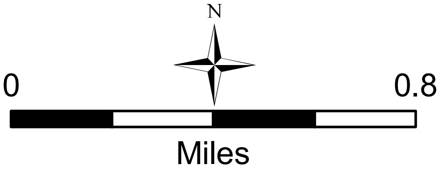
Mono Lake Landtype, Historical Conditions

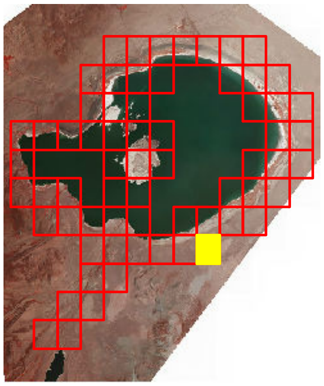
Landtype Legend

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow

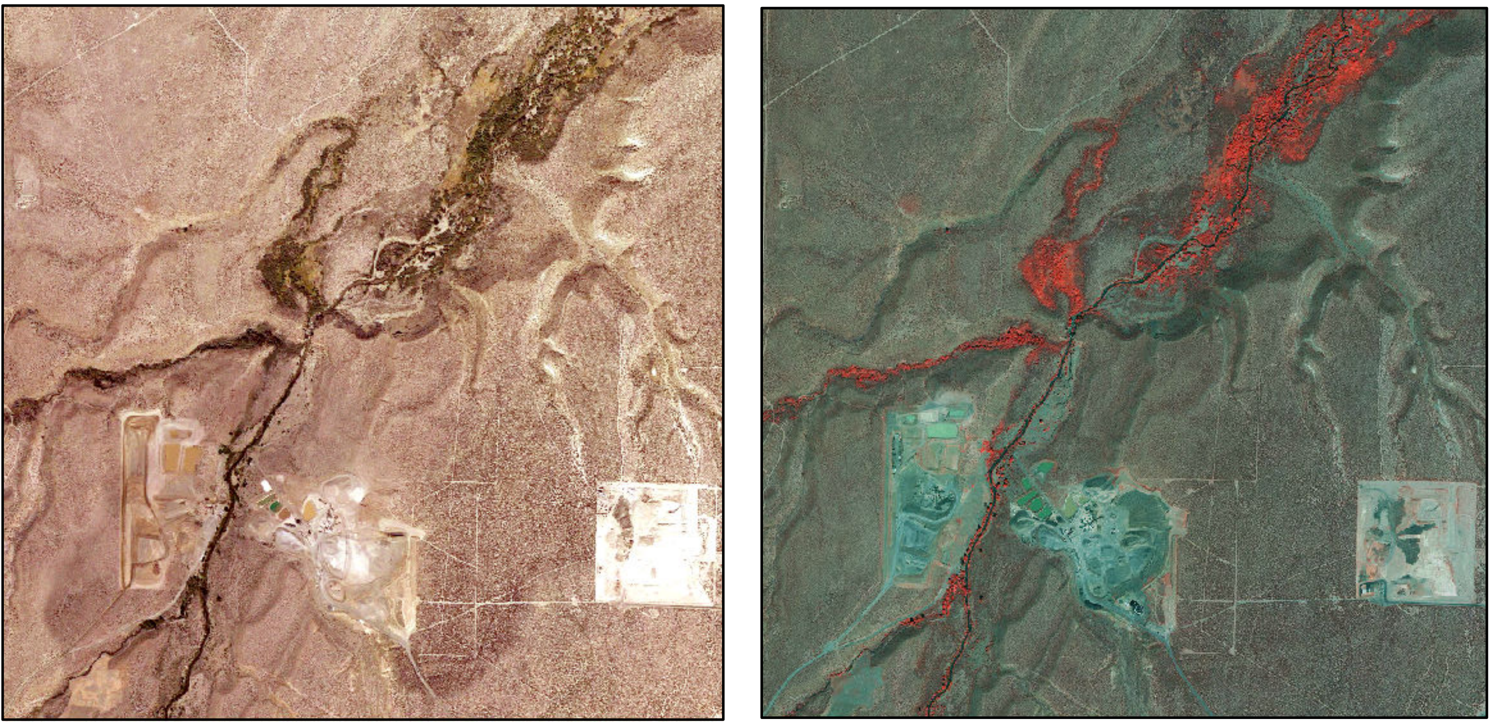
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map H9



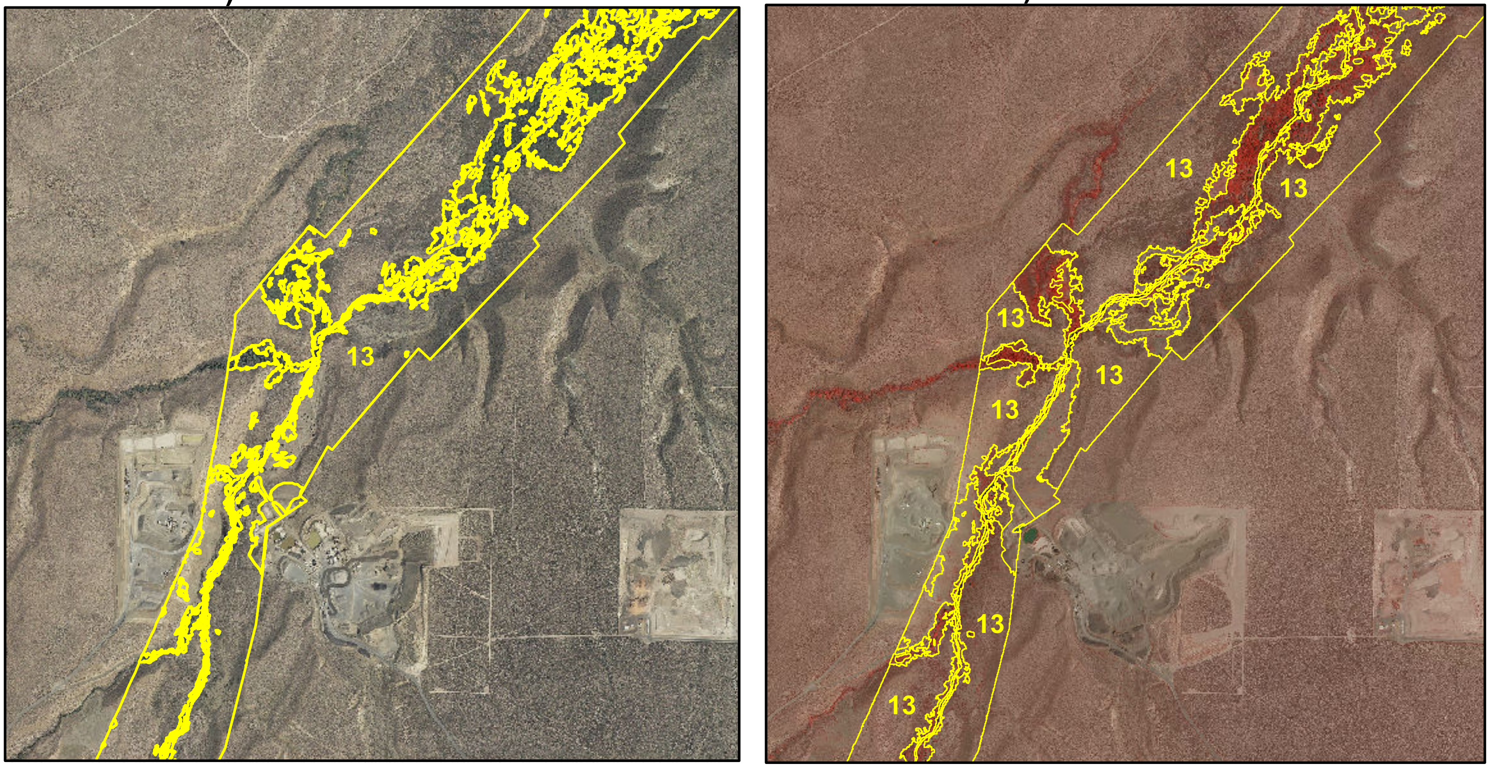


Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.



A) 1999 conditions.

B) 2005 conditions.



C) 2009 conditions.

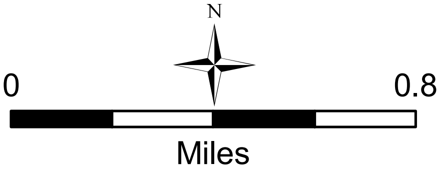
D) 2014 conditions.

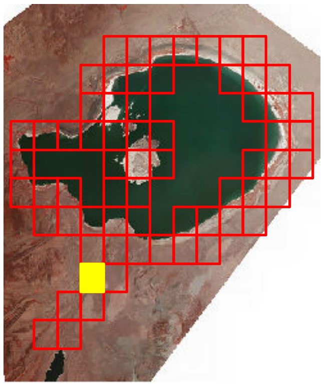
Mono Lake Landtype, Historical Conditions

Landtype Legend

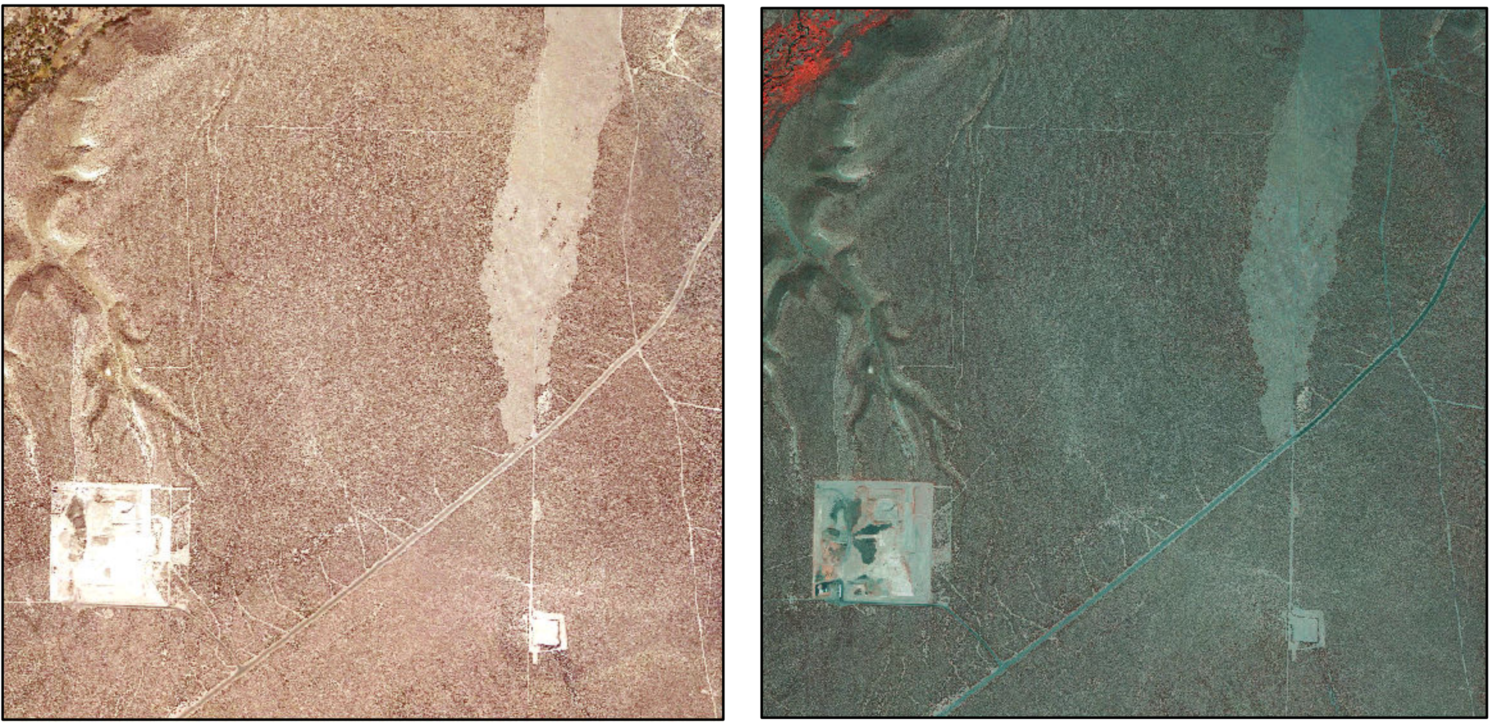
1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map I4



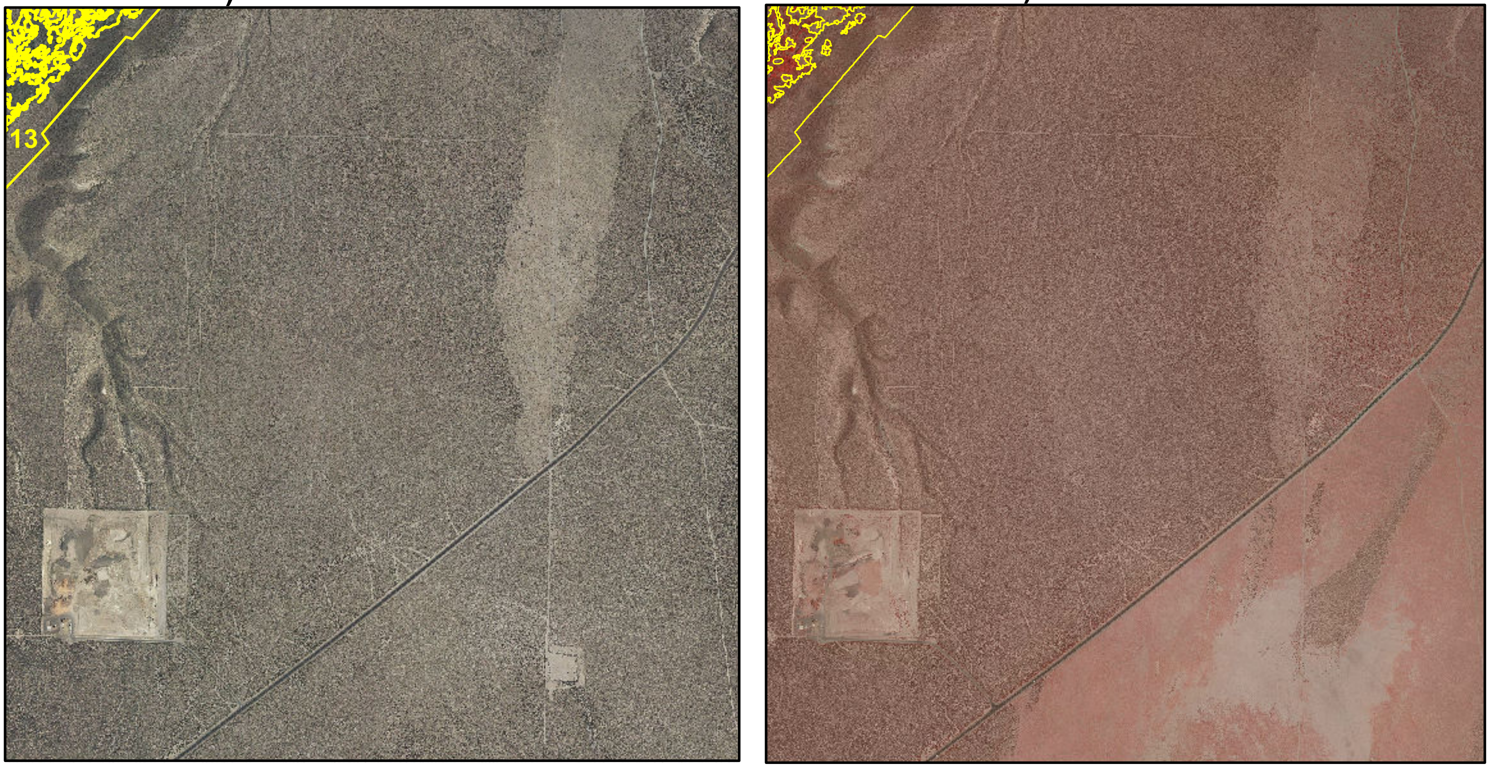


Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.



A) 1999 conditions.

B) 2005 conditions.



C) 2009 conditions.

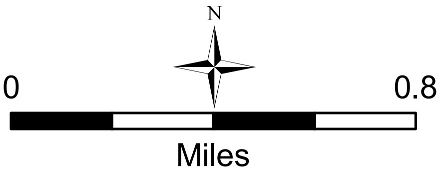
D) 2014 conditions.

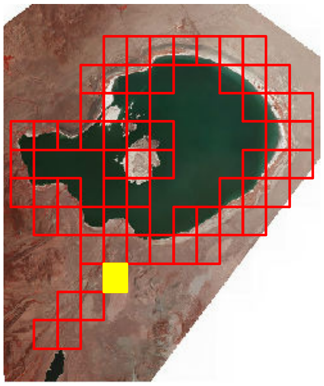
Mono Lake Landtype, Historical Conditions

Landtype Legend

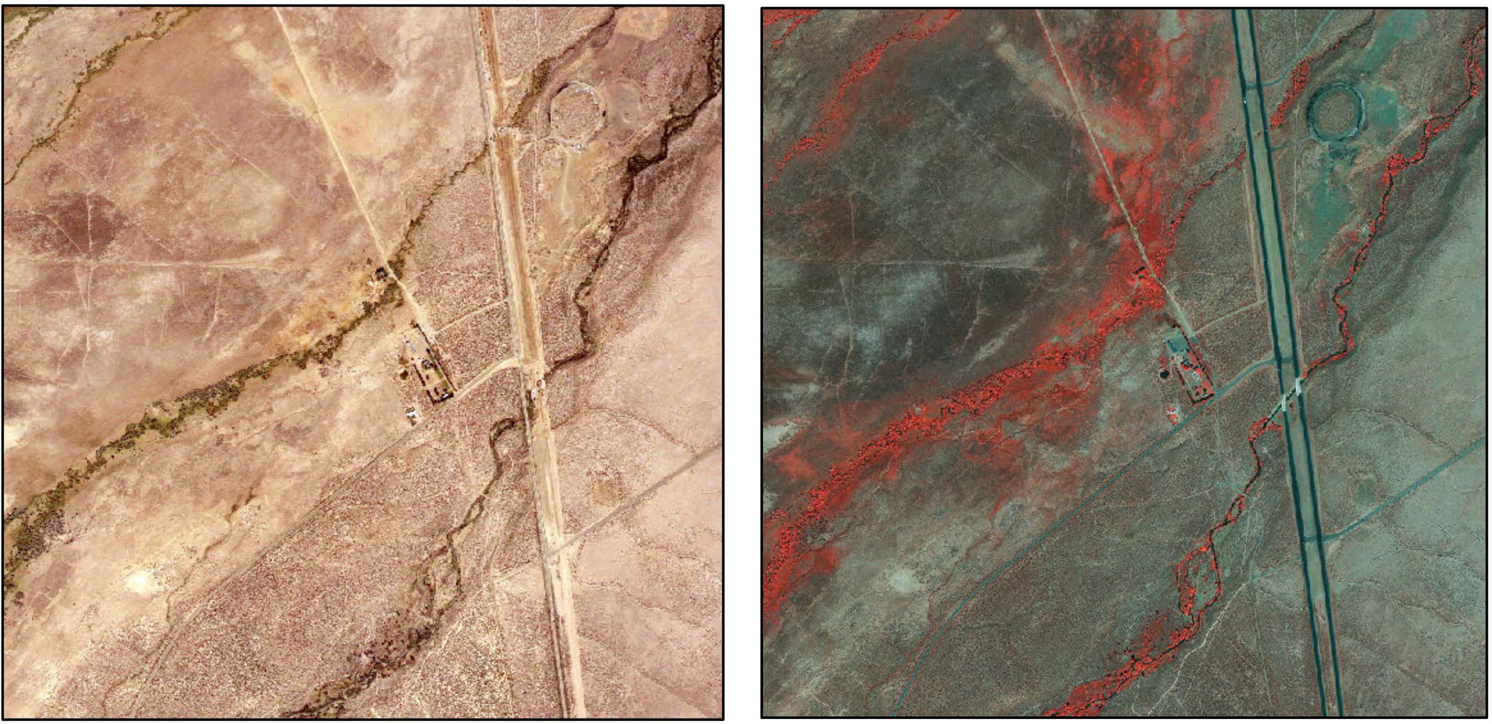
1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map I5

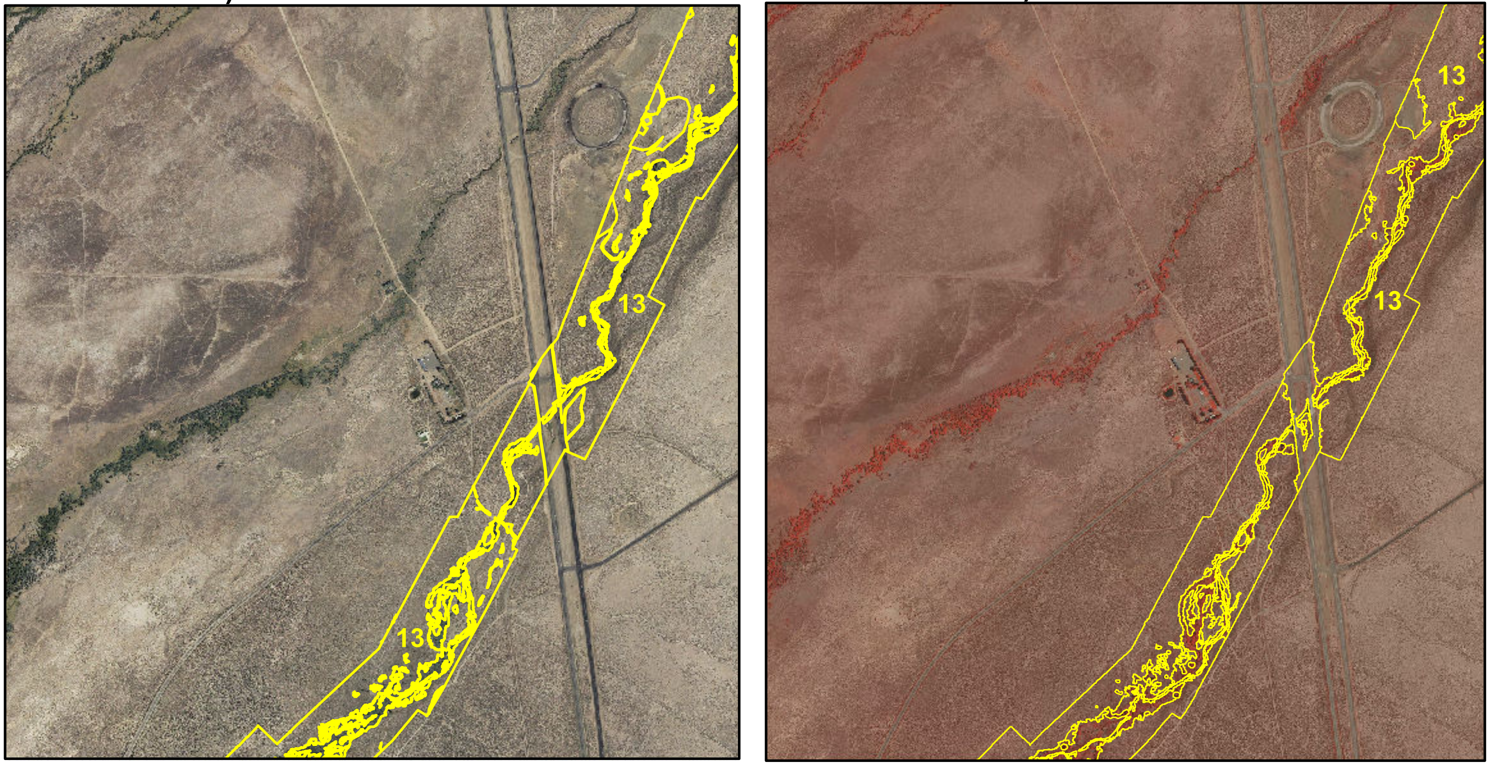




Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.



A) 1999 conditions. **B) 2005 conditions.**



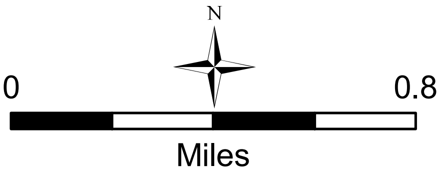
C) 2009 conditions. **D) 2014 conditions.**

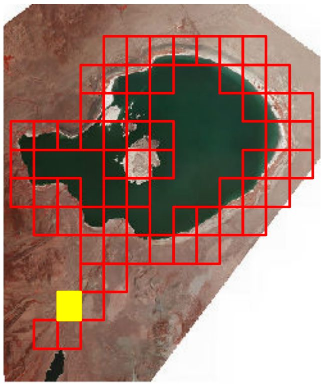
Mono Lake Landtype, Historical Conditions

Landtype Legend

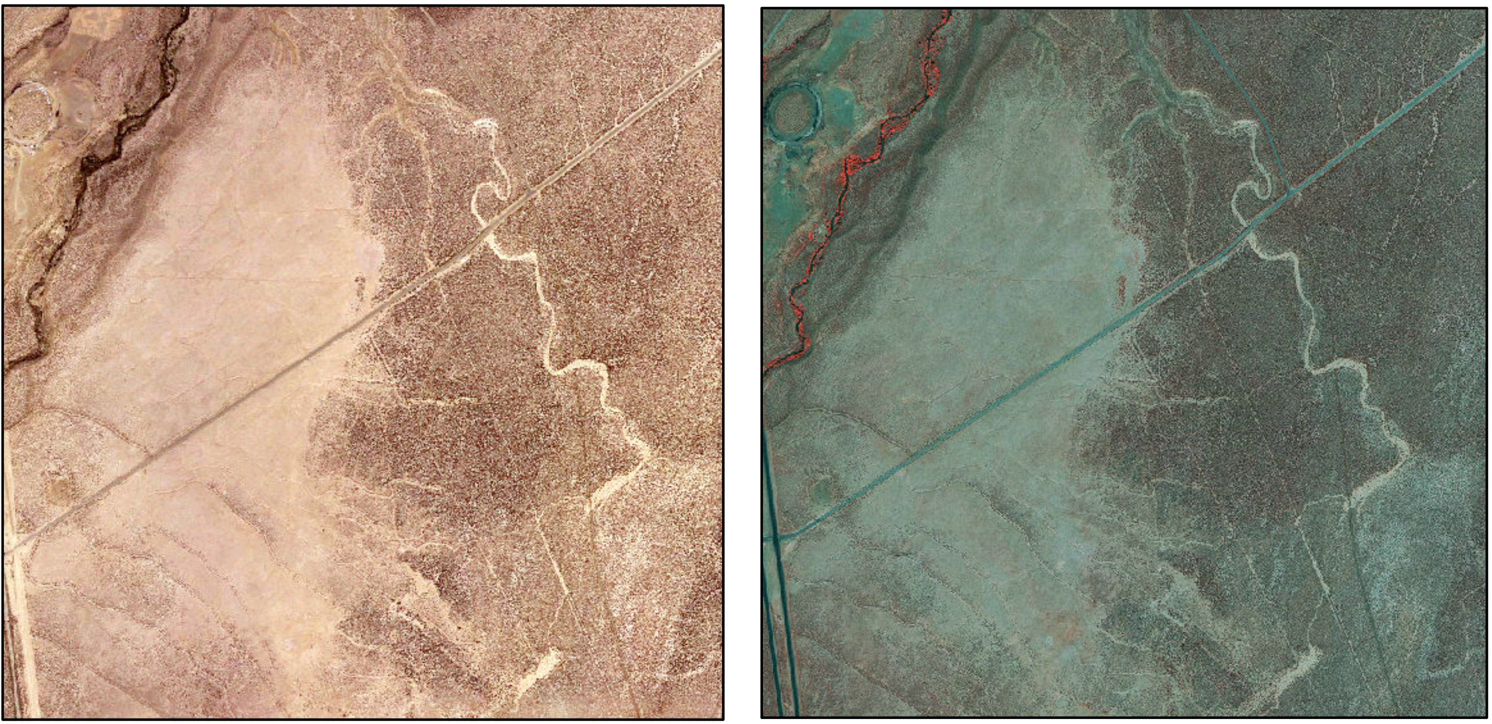
1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map J3



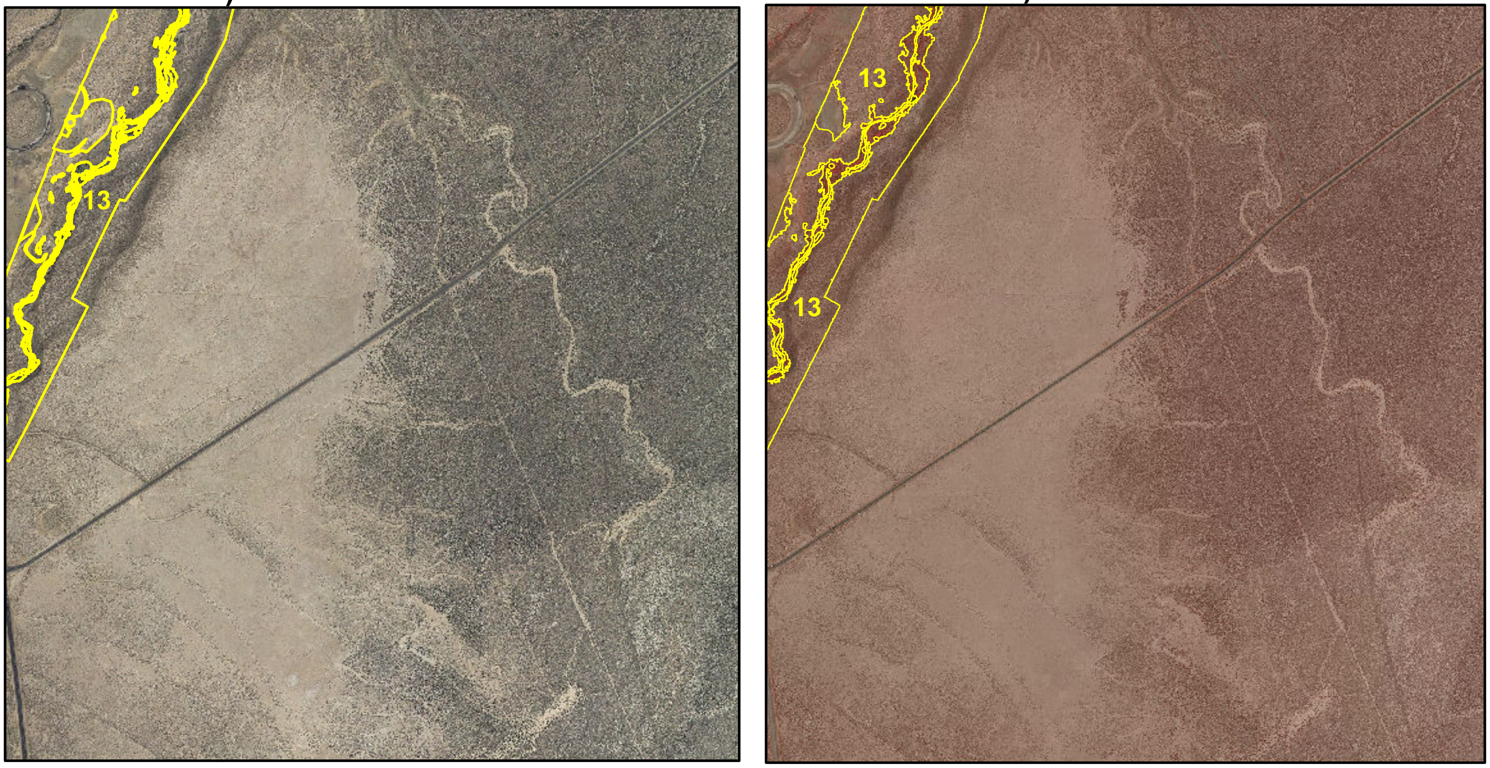


Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.



A) 1999 conditions.

B) 2005 conditions.



C) 2009 conditions.

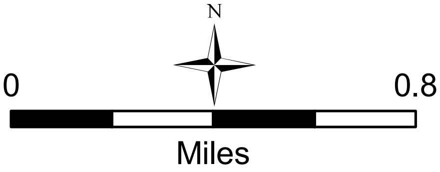
D) 2014 conditions.

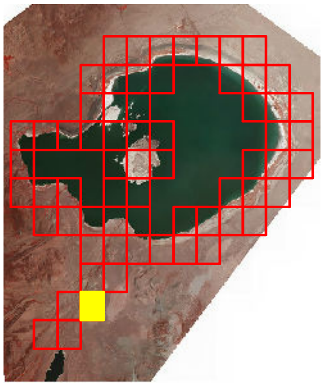
Mono Lake Landtype, Historical Conditions

Landtype Legend

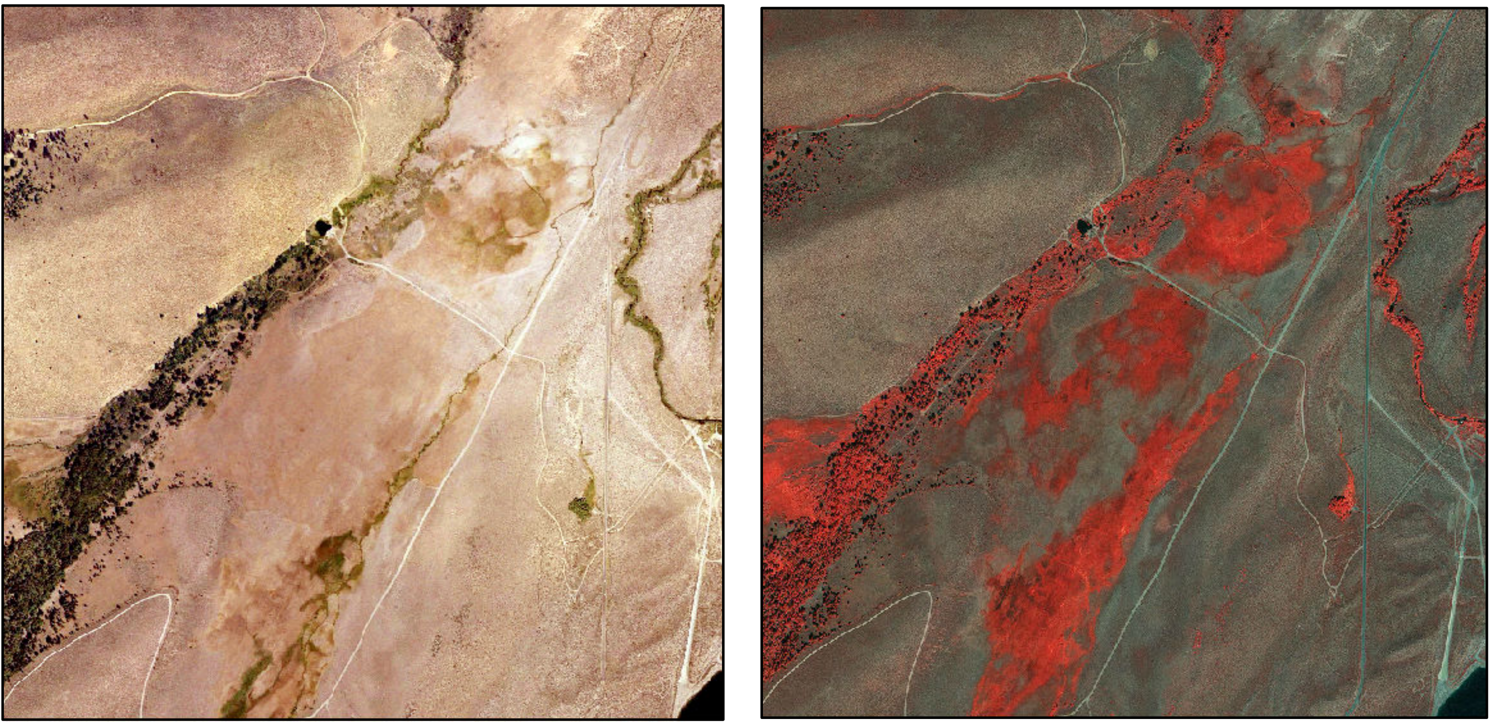
1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map J4



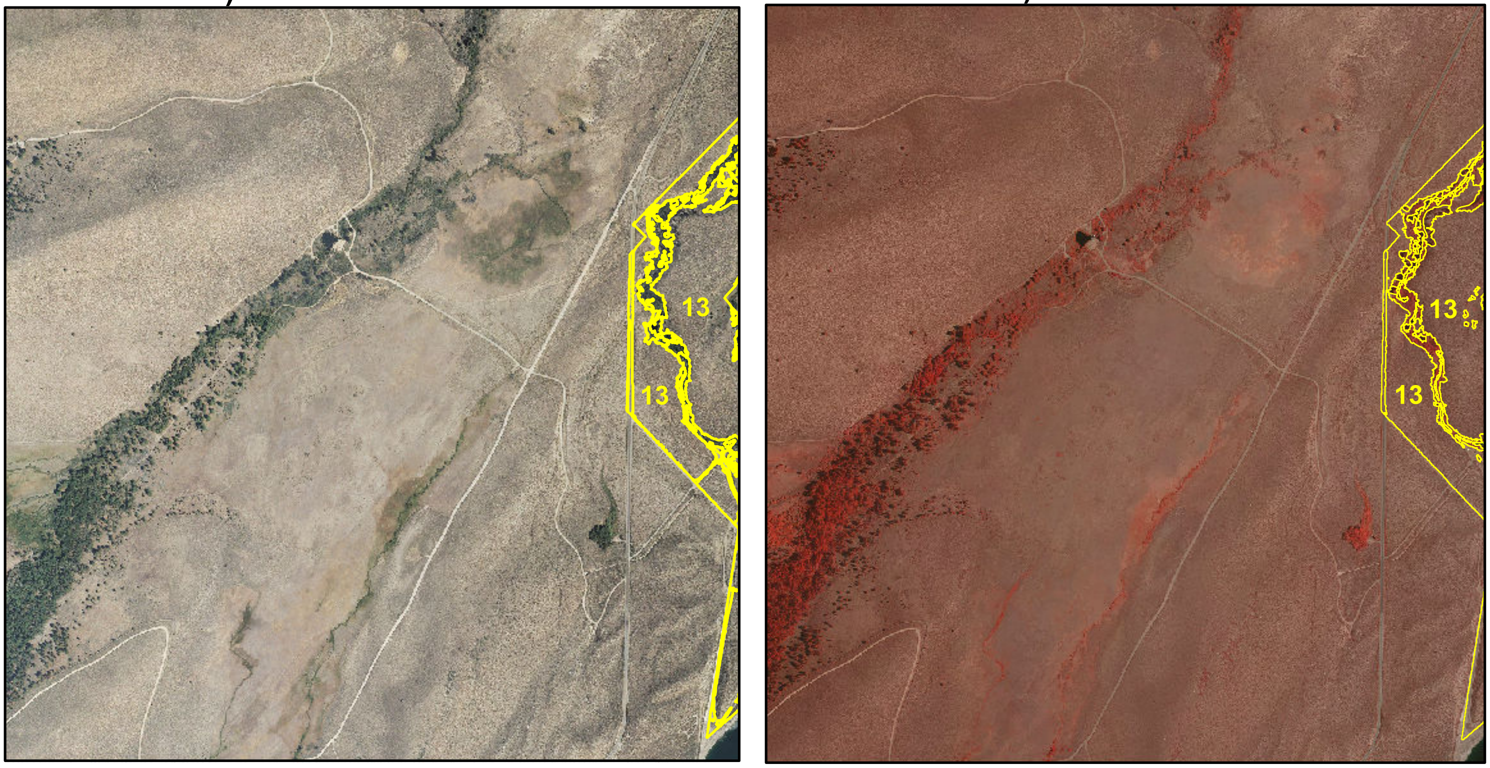


Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.



A) 1999 conditions.

B) 2005 conditions.



C) 2009 conditions.

D) 2014 conditions.

Mono Lake Landtype, Historical Conditions

Landtype Legend

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
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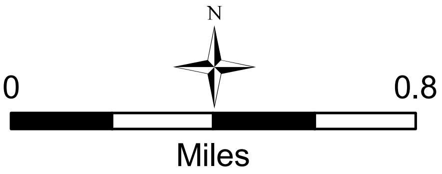
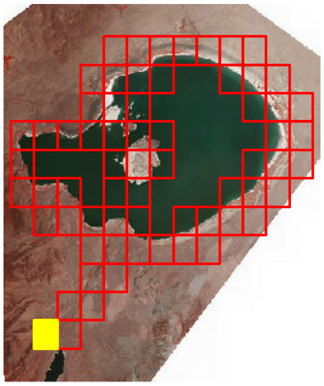
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map K2

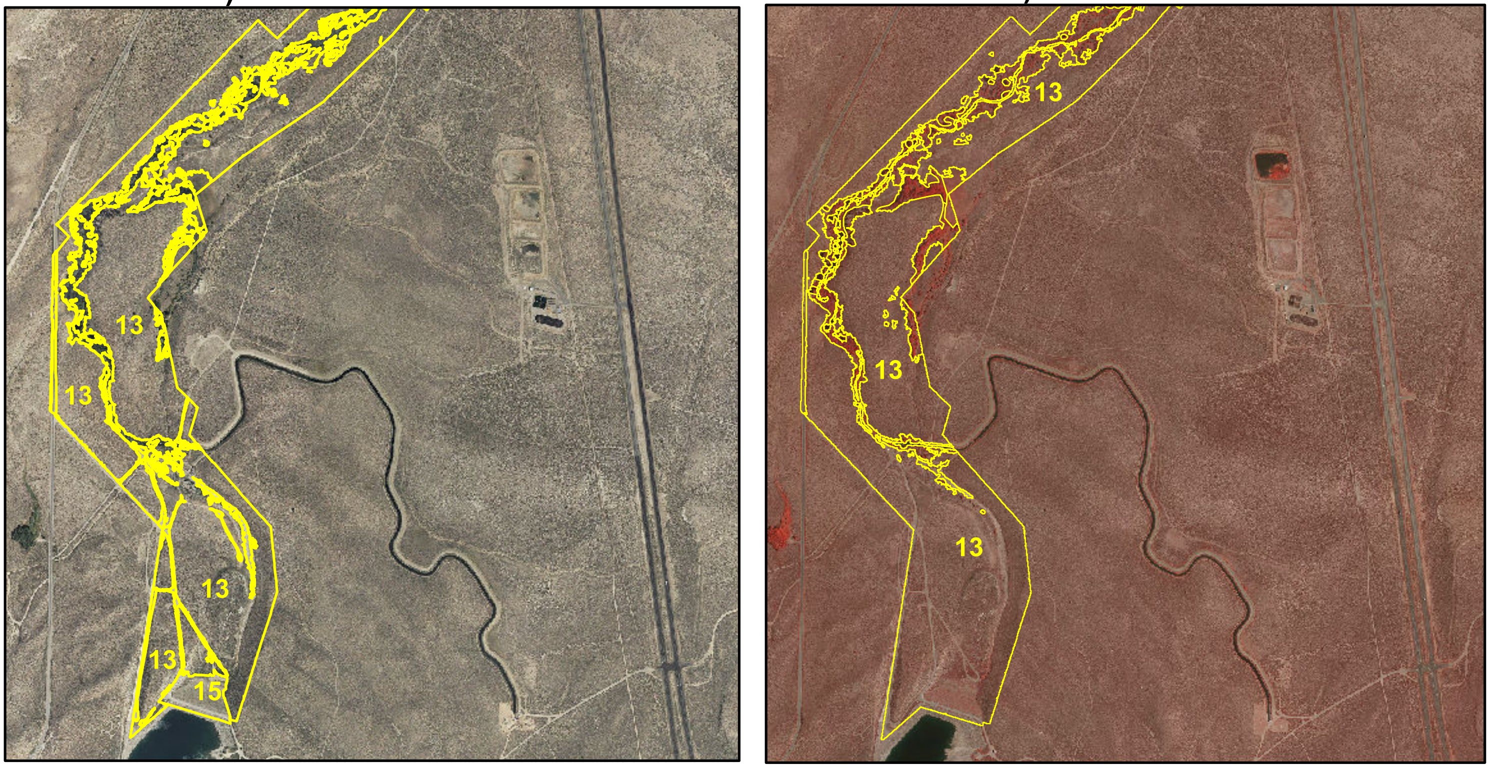




Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.

A) 1999 conditions.

B) 2005 conditions.



C) 2009 conditions.

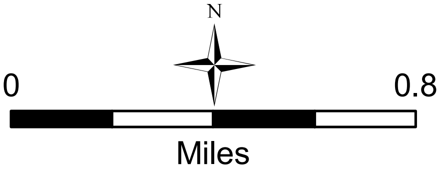
D) 2014 conditions.

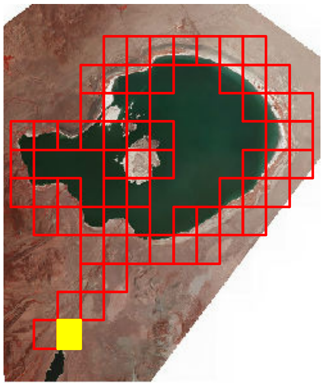
Mono Lake Landtype, Historical Conditions

Landtype Legend

1 = Freshwater stream
2 = Freshwater pond
3 = Ria
4 = Ephemeral brackish lagoon
5 = Hypersaline lagoon
6 = Mudflat
7 = Marsh
8 = Wet meadow
9 = Alkaline wet meadow
10 = Dry meadow/forb
11 = Riparian shrub
12 = Riparian woodland
13 = Great Basin scrub
14 = Unvegetated
15 = Man-made

Map K3





Note: Small parcels are left unlabeled to reduce map clutter. Great Basin scrub includes rabbitbrush scrub and eolian delineated for 2014 conditions.