Relicensing Study 3.3.1

Conduct Instream Flow Habitat Assessments in the Bypass Reach and below Cabot Station

Study Report

Addendum 6 Assessment of Sea Lamprey (new spawning HSI curves) and Yellow Lampmussels in Reach 4

Northfield Mountain Pumped Storage Project (No. 2485)

and Turners Falls Hydroelectric Project (No. 1889)

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cfs	cubic feet per second
cm	centimeters
FERC	Federal Energy Regulatory Commission
FL	FirstLight Hydro Generating Company
ft	feet
ft/s	feet per second
HEC-RAS	Hydrologic Engineering Center River Analysis System
HEC-ResSim	Hydrologic Engineering Center Reservoir System Simulation
HSI	Habitat Suitability Index
in	inches
MADFW	Massachusetts Division of Fisheries & Wildlife
NHESP	Natural Heritage and Endangered Species Program
NMFS	National Marine Fisheries Service
PHABSIM	Physical Habitat Simulation
ROR	Run-of-river
SI	Suitability Index
USFWS	United States Fish and Wildlife Service
WSEL	water surface elevation
WUA	weighted usable area

1 INTRODUCTION

On October 14, 2016, FirstLight Hydro Generating Company (FL) filed with the Federal Energy Regulatory Commission (FERC) Study Report No. 3.3.1 Instream Flow Habitat Assessment in the Bypass Reach and below Cabot Station.

Between April 3, 2017 and May 1, 2018, FL filed the following additional addendums to Study No. 3.3.1:

- Addendum 1- Addressed Miscellaneous Comments Provided on the Original Study 3.3.1 filing
- Addendum 2- Instream Flow Study Results for Mussels in Reach 5
- Addendum 3- Yellow Lampmussel Assessment in Reach 3
- Addendum 4- Sea Lamprey Assessment with new Habitat Suitability Index Curves

On October 9, 2018, FL held a Study Report Meeting in which Addendums 1-4 were discussed and filed its meeting summary on October 24, 2018 per FERC regulations. Stakeholder comments on the meeting summary and addendums were due by November 23, 2018. Comments on Study No. 3.3.1 were filed by the United States Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS) and the Massachusetts Division of Fisheries & Wildlife (MADFW). Some of the comments filed on Study No. 3.3.1 requested additional information. On December 21, 2018, FL filed its response to comments with FERC. In its responsiveness summary, FL agreed to provide the following additional information by March 1, 2019.

- Persistent habitat maps for Reach 3 and dual flow results for Reach 4 for the new Sea Lamprey Habitat Suitability Index Curves.
- Persistent habitat mapping of juvenile Yellow Lampmussels in Reach 3 over a range of Project Operations.

On January 22, 2019, FERC issued its Study Plan Determination. Relative to Study No. 3.1.1 it states: "*FirstLight should evaluate the 4-variable (depth, substrate, benthic velocity and shear stress) WUA versus flow relationship, conduct a dual flow analysis using the 4-variable WUA and conduct shear stress mapping for adult and juvenile yellow lampmussel at the range of flows modeled in Reach 4 for other species (1,200 to 37,500 cfs)*". FERC stated that the requested information should be filed within 90 days or by April 22, 2019.

Note that although FL proposed to file the dual flow analysis for the new Sea Lamprey Habitat Suitability Index Curves in Reach 4 by March 1, 2019 in its March 1, 2019 cover letter it indicated that it will be filed on April 22, 2019. Thus, all of the Reach 4 analysis for Yellow Lampmussel and Sea Lamprey spawning is included in this document- Addendum 6. In addition to the dual flow analysis, FL also conducted a persistent habitat analysis for Sea Lamprey as described later in this report.

2 METHODS

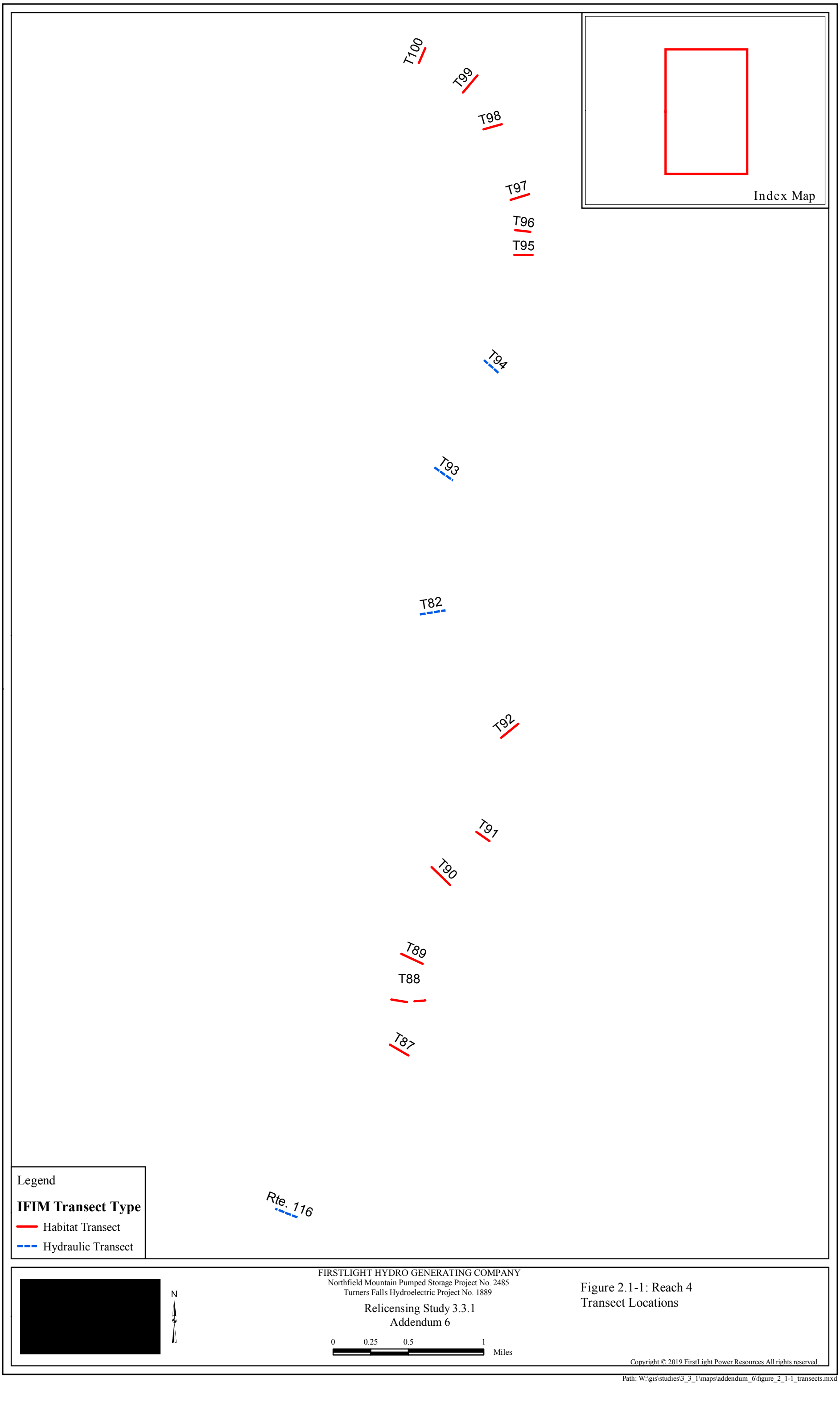
2.1 Hydrologic and Hydraulic Modeling

Study No. 3.8.1 *Evaluate the Impact of Current and Potential Future Modes of Operation on Flow, Water Elevation, and Hydropower Generation* used the HEC-ResSim modeling software to develop an operations model of the Connecticut River from the Wilder Project to the Holyoke Project. The model was operated on an hourly basis and was used to determine flow and power production for the period of record: January 1, 1962 to December 31, 2003. Specifically, FL used the operations model to simulate two scenarios- baseline (existing) conditions and run-of-river (ROR) operations. Under the ROR operation, the Wilder, Bellows Falls, Vernon and Turners Falls Projects were operated as ROR, while Northfield Mountain operated as it currently does. Although the ROR scenario simulated Northfield Mountain under its current operation, the flow regime below Cabot was maintained smooth as the Turners Falls Impoundment (TFI) was used to buffer times of pumping and generating. Also, under both the baseline and ROR scenarios, the bypass flows reflected current minimum flow requirements.

The HEC-ResSim model output includes hourly flows at Montague which is a combination of: bypass flows (including Station No.1 generation and spill at Turners Falls Dam), Cabot Station generation flows, and Deerfield River flows for the period of record. The Montague flows from the HEC-ResSim model were used as inflows to the HEC-RAS model[1] along with the intervening tributaries between Montague and Holyoke Dam. The HEC-RAS model operates on an hourly time step from January 1, 1962 to December 31, 2003 and was used to calculate the hourly flow at each transect within Reach 4. Reach 4 extends from Montague to the Sunderland (Route 116) Bridge, an approximate 9-mile long reach. The downstream boundary condition for the hydraulic model is the water surface elevation (WSEL) at Holyoke Dam which is controlled by Holyoke Gas and Electric. Per its FERC license the water level range at the Holyoke Dam is between elevations of 99.47 and 100.67 ft NGVD 1929. As described in the Study 3.2.2 Report, the Holyoke Dam WSELs normally has a limited influence on the WSELs and flows in Reach 4. However, for this Addendum, the WSELs and flows which were used at each cross section in Reach 4 are based on the average of two model runs, one with a downstream boundary condition of 99.47 ft and the other at 100.67 ft.

As part of Study No. 3.3.1 *Instream Flow Habitat Assessments in the Bypass Reach and below Cabot Station*, a PHABSIM 1-D model was used to analyze the habitat in Reach 4, which is described in the document. The model consists of 12 transects (Figure 2.1-1) and additional hydraulic transects, which corresponds to transects within the HEC-RAS hydraulic model. Substrate data for these transects were obtained during the field work described in the Study 3.3.1 Report. As part of the analysis conducted for Study 3.3.1, later addendums, and this addendum, habitat versus flow relationships were developed at each incremental station along the transects based on the habitat suitability index (HSI) values for mussels and the revised HSI values for Sea Lamprey spawning.

[1] The HEC-RAS model is described in Study No. 3.2.2 *Hydraulic Study of Turners Falls Impoundment, Bypass Reach and Below Cabot*



FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

Relicensing Study 3.3.1
Addendum 6

Figure 2.1-1: Reach 4
Transect Locations

Path: W:\gis\studies\3_3_1\maps\addendum_6\figure_2_1-1_transects.mxd

2.2 Flow Time Series Data Processing

Conversion

The HEC-RAS modeled flow values were converted to the nearest flow value that was used to create the habitat vs flow relationships at each habitat transect. Conversion was chosen over interpolation between modeled values because, unlike standard weighted usable area (WUA) versus habitat relationships, persistent or dual flow habitat may not be adequately represented by interpolation between modeled values due to spatial shifts in habitat. Flow values above or below the modeled habitat range were considered to be equal to the highest or lowest modeled habitat flow, respectively.

Flows Encountered by Cohorts

Analysis of persistent habitat was performed on a cohort-specific basis for juvenile Yellow Lampmussel and Sea Lamprey spawning in Reach 4, as follows:

- Juvenile Yellow Lampmussel cohorts were analyzed over a 2-year-long juvenile period. The first four months for each cohort (June through September) was considered to be the critical flow window for juvenile mussel settling and burrowing into the substrate, as discussed with the Natural Heritage and Endangered Species Program (NHESP) on May 25th, 2018. For this time period, a list of unique flows that occurred was developed for each cohort from the full flow time series. An additional list of unique flow rates for the remaining 20 months of each cohort was also developed.
- Adult Yellow Lampmussel were analyzed based on the persistent habitat available over the course of each year (January 1 through December 31) in the time series. For each year, a list of unique flows that occurred was developed from the full flow time series.
- Sea Lamprey spawning cohorts were analyzed over the span of the Sea Lamprey spawning season, from May 20 through July 31. For this time period, a list of unique flows that occurred was developed for each cohort from the full flow time series.

2.3 Persistent Habitat Analysis

Persistent habitat was analyzed spatially at each transect by overlaying station cells from the PHABSIM model for all unique flows and associated suitable habitat that occurred for each cohort. Any areas that did not contain suitable habitat during any flow that was experienced were assigned an unsuitable value for persistent habitat for that cohort. This habitat time series analysis was performed based on hourly flows from the operations model routed through the hydraulic model that encompassed the years 1962 through 2003. As such, the analysis encompassed persistent habitat over the range of the combination of natural and operational flows based on available water during that time period. The results are shown spatially in terms of the areas where persistent suitable habitat was available for a proportion of cohorts in the analysis. Additionally, the total amount of persistent habitat within a cross-section was calculated for each cohort based on the length (in feet) of the cross-sectional perimeter that was found to be persistently suitable. The criteria used to develop the persistent habitat time series results are shown in the following subsections for Juvenile Yellow Lampmussel, Adult Yellow Lampmussel, and Sea Lamprey spawning.

2.3.1 Juvenile Yellow Lampmussel

For the first four months (June through September) of a cohort, flow was converted to habitat based on 4-variable habitat suitability criteria, which included depth, velocity, substrate criteria developed initially for Study No. 3.3.1 by a panel of experts using the Delphi technique (Table 2.3.1-1), along with shear stress at 10 dynes/cm^2, as requested by NHESP. For the remaining 20 months in the cohort, the same depth, velocity,

and substrate criteria were used, along with a shear stress value of 150 dynes/cm^2, as requested by NHESP. The lower shear stress criteria during the first four months of each cohort was requested by NHESP for successful settling and burrowing; the higher shear stress during the remainder of each cohort period was requested by NHESP because during this time, the mussels would be larger and burrowed into the substrate, and would therefore be less susceptible to the effects of shear stress.

Table 2.3.1-1: Binary Habitat Suitability Criteria Developed for Juvenile Yellow Lampmussel.

Parameter		Yellow Lampmussel Juvenile
Class	**Benthic Velocity Range (ft/s)**	
1	<0.16	1
2	0.16-0.34	1
3	0.35-0.67	1
4	0.68-0.99	1
5	1.00-1.32	1
6	1.33-1.65	1
7	1.66-2.47	0
8	2.48-3.29	0
9	3.30-4.93	0
10	4.94-6.56	0
11	>6.56	0
Class	**Water Depth Range (ft)**	
1	0	0
2	0.03-0.34	0
3	0.35-0.83	1
4	0.84-1.65	1
5	1.66-2.47	1
6	2.48-3.29	1
7	3.30-4.93	1
8	4.94-6.56	1
9	6.57-9.85	1
10	9.86-13.12	1
11	>13.12	1
Class	**Particle Size**	
1	Organic Material	0
2	Clay	0
3	<0.002 in [mud/silt]	1
4	0.002 – 0.08 in. [sand]	1
5	0.08- 1.26 in. [fine gravel]	1
6	1.26 – 2.52 in. [coarse gravel]	1
7	2.52 – 5.90 in. [small cobble]	1
8	5.90 – 9.84 in. [large cobble]	0
9	9.84 – 157.5 in. [boulder]	0
10	Bedrock	0

2.3.2 Adult Yellow Lampmussel

For adult Yellow Lampmussel, flows encountered each year were converted to habitat based on 4-variable habitat suitability criteria, which included depth, velocity, substrate criteria developed initially for Study No. 3.3.1 by a panel of experts using the Delphi technique (Table 2.3.2-1), along with shear stress at 150 dynes/cm^2, as requested by NHESP.

Table 2.3.2-1: Binary Habitat Suitability Criteria Developed for Adult Yellow Lampmussel.

Parameter		Yellow Lampmussel Adult
Class	**Benthic Velocity Range (ft/s)**	
1	<0.16	1
2	0.16-0.34	1
3	0.35-0.67	1
4	0.68-0.99	1
5	1.00-1.32	1
6	1.33-1.65	1
7	1.66-2.47	1
8	2.48-3.29	0
9	3.30-4.93	0
10	4.94-6.56	0
11	>6.56	0
Class	**Water Depth Range (ft)**	
1	0	0
2	0.03-0.34	0
3	0.35-0.83	1
4	0.84-1.65	1
5	1.66-2.47	1
6	2.48-3.29	1
7	3.30-4.93	1
8	4.94-6.56	1
9	6.57-9.85	1
10	9.86-13.12	1
11	>13.12	1
Class	**Particle Size**	
1	Organic Material	0
2	Clay	0
3	<0.002 in [mud/silt]	1
4	0.002 – 0.08 in. [sand]	1
5	0.08- 1.26 in. [fine gravel]	1
6	1.26 – 2.52 in. [coarse gravel]	1
7	2.52 – 5.90 in. [small cobble]	1
8	5.90 – 9.84 in. [large cobble]	0
9	9.84 – 157.5 in. [boulder]	0
10	Bedrock	0

2.3.3 Sea Lamprey Spawning

Habitat time series analysis was performed based on flows from the operations model routed through the hydraulic model that encompassed the years 1962 through 2003. Flows were converted to habitat using the habitat suitability criteria for Sea Lamprey spawning (Figures 2.3.3-1 (depth), Figure 2.3.3-2 (velocity) and Figure 2.3.3-3 (substrate)). Persistent habitat was analyzed based on a Combined Suitability (SI) ≥ 0.5, which was considered "Quality Habitat" in previous reports. In Addendum 4 of Study 3.3.1 dated May of 2018, FL calculated the total WUA area in Reach 4 based on the old and new HSI curves and the comparison from Addendum 4 is shown in Figure 2.3.3-4. In general, the new HSI curves, which are what were used in this addendum, produced a much larger amount weighted useable area, but the area decreases rapidly with higher flows

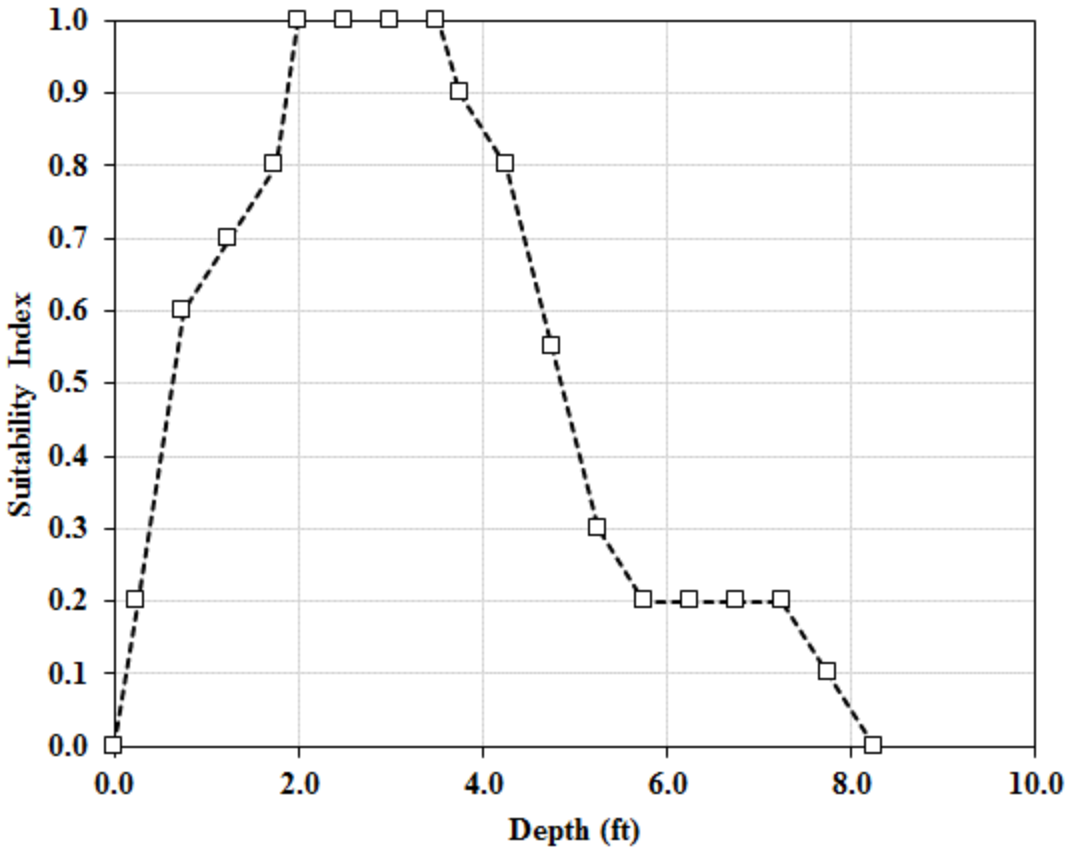


Figure 2.3.3-1: Depth Suitability Criteria for Sea Lamprey Spawning.

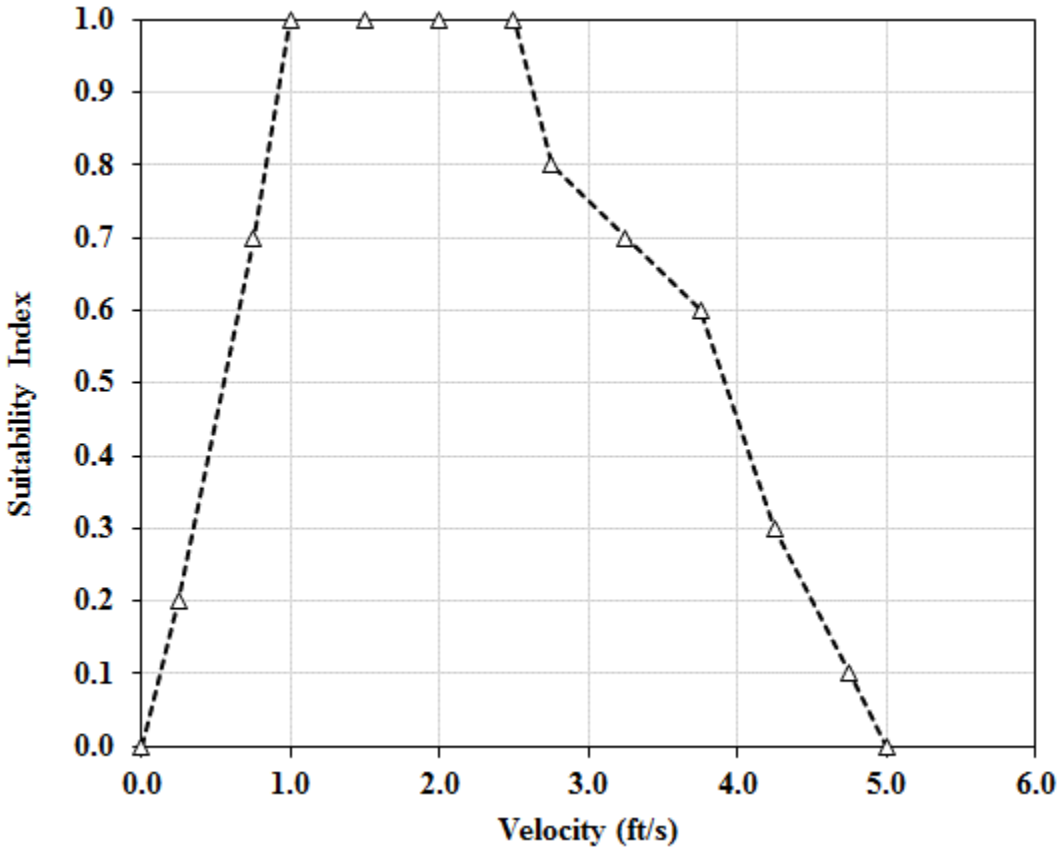


Figure 2.3.3-2: Velocity Suitability Criteria for Sea Lamprey Spawning.

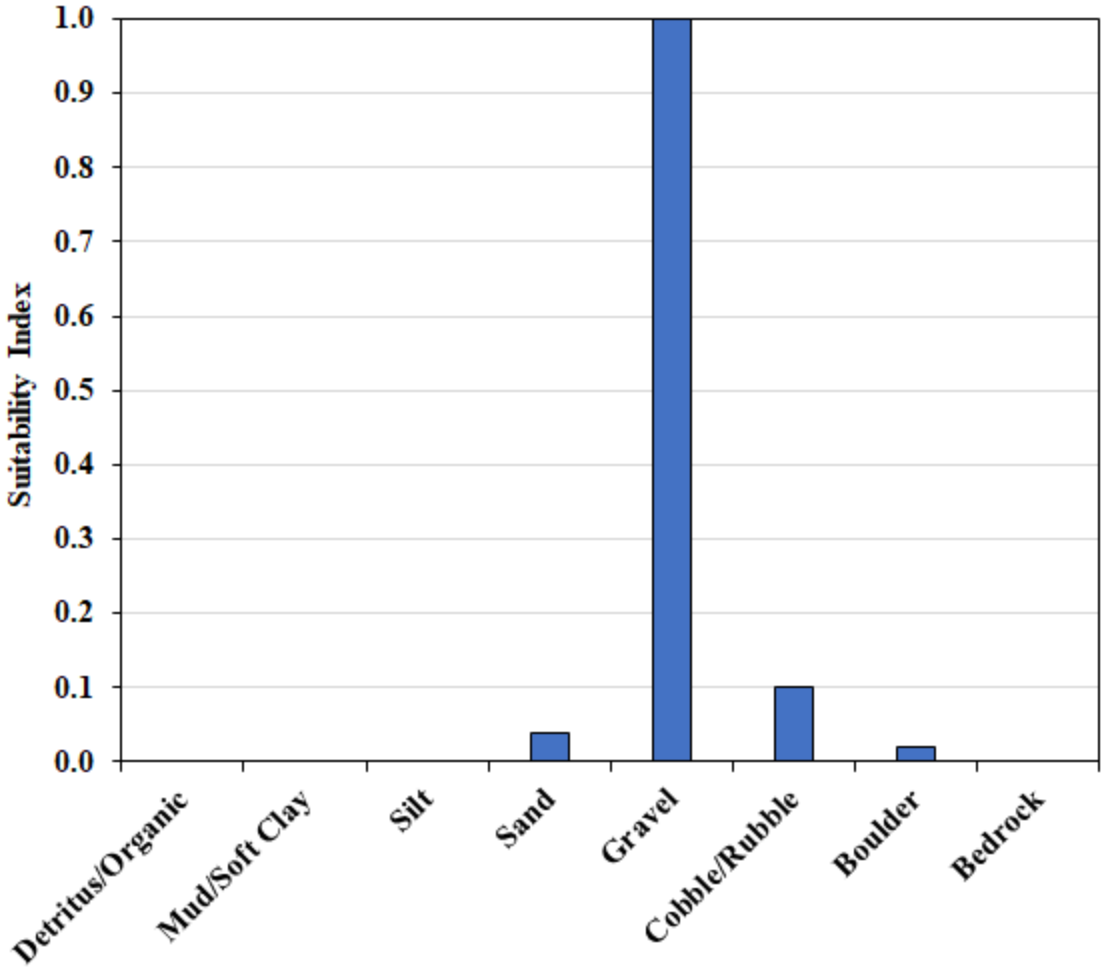


Figure 2.3.3-3: Substrate Suitability Criteria for Sea Lamprey Spawning.

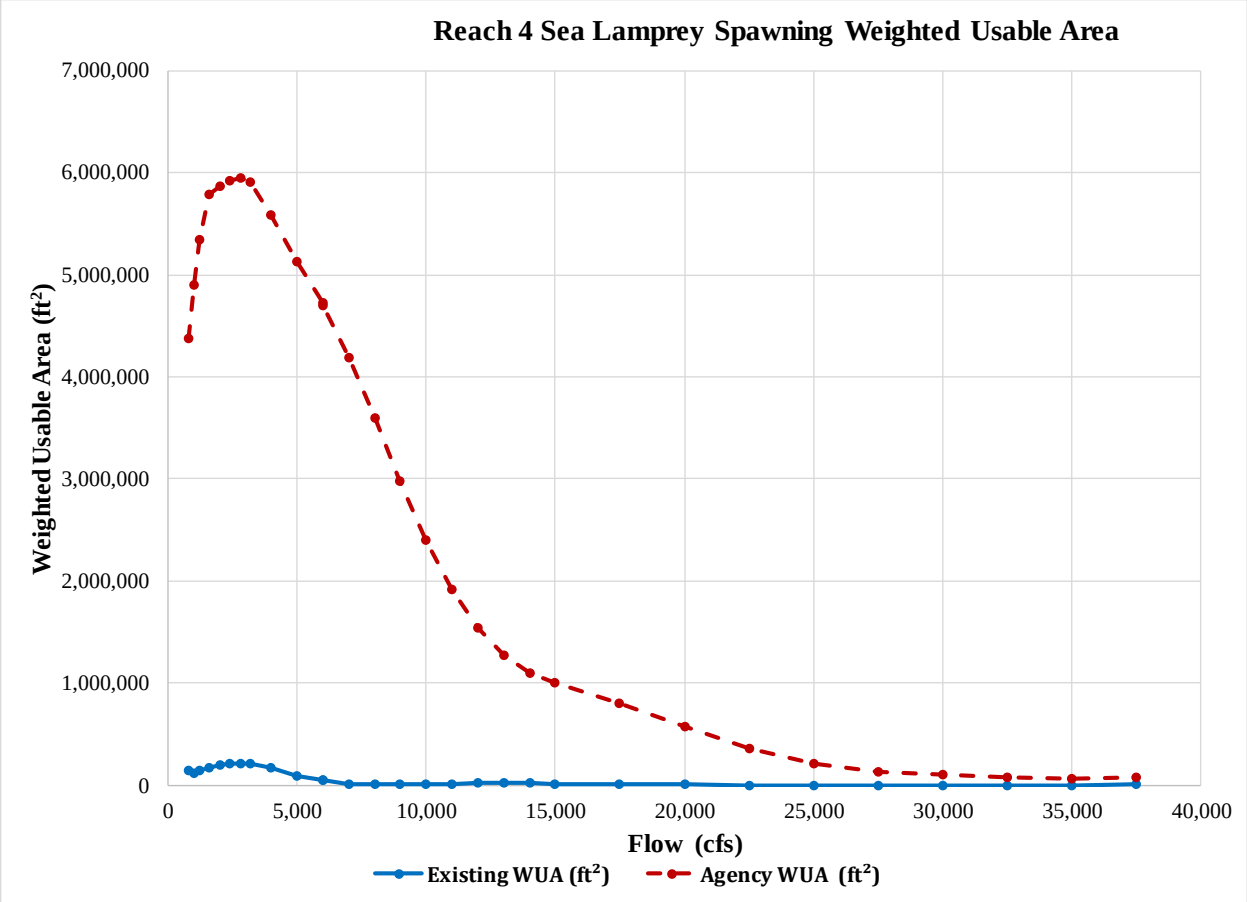


Figure 2.3.3-4: Comparison of Weighted Usable Areas Calculated with the Old (Existing) and New (Agency) HSI Curves.

2.4 Dual Flow Analysis for Sea Lamprey Spawning

A dual flow analysis was conducted for Reach 4, and is in some ways similar to persistent habitat analysis. It calculates the quantity of habitat and quality habitat (defined as CF(I) ≥ 0.5) present over paired base flow and higher flows across a range of scenarios, as those that may be expected during a minimum flow/peaking flow hydropower operation. In this analysis, it also includes flows in excess of the project generation capacity (about 16,000 cfs) up to 37,500 cfs, which is the upper end of the modeling range in Reach 4. The resulting flow combinations ranged from 1,200 cfs to 37,500 cfs. Dual flow habitat was calculated using the series of rectangular habitat cells for each transect. As streamflow varies, habitat may decrease in some cells, while increase in others. For immobile target species such as Sea Lamprey Spawning, an assumption was made that the available habitat is the minimum available in each cell between a given pair of flows. The PHABSIM program calculated these minimum habitat cell values for a dual flow combination and summed them for a particular transect. The habitat for dual flow combinations is equal to, or less than, the minimum of the two steady state flow habitat values calculated for each of the two flows. The dual flow results for each transect in Reach 4 were weighted in the same manner used in Study 3.3.1 and related addendums. The flows used in the Dual Flow Tables are provided below:

- 1,200 cfs;
- 1,600 cfs;
- 2,000 cfs;
- 2,800 cfs;
- 4,000 cfs;
- 5,000 cfs;
- 6,000 cfs;
- 8,000 cfs;
- 10,000 cfs;
- 12,000 cfs;
- 14,000 cfs;
- 15,000 cfs;
- 17,500 cfs;
- 20,000 cfs;
- 25,000 cfs;
- 30,000 cfs; and
- 37,500 cfs.

3 RESULTS

3.1 Juvenile Yellow Lampmussel

Habitat time series data were developed for forty 2-year juvenile Yellow Lampmussel cohorts using flow time series data from 1962 through 2003 (42-year hourly time step operations model). Spatially, the amount of juvenile Yellow Lampmussel habitat in Reach 4 that persisted over the span of a 2-year juvenile mussel cohort varied considerably among transects (Figure 3.1-1).[2] The overall distribution in the amount of persistent habitat available at each transect was similar between the modeled Baseline and ROR conditions. Detailed information regarding the locations of persistent habitat at each transect for cohorts in the time series are shown in Appendix A.

The two transects with the greatest amounts of juvenile Yellow Lampmussel habitat were T87 and T88 (see Figure 2.1-1). These transects were the furthest downstream transects in the reach and were located around Second Island.

[2] Boxplots are a standardized statistical visualization method to compare distributions of values. Each boxplot within a given plot shows the distribution of habitat amount values that would have been predicted to occur at each transect and modeled flow scenario across all years analyzed. Each box spans the 25th to 75th percentile values, and the median value is shown within the box. The distance between the 25th and 75th percentile is known as the interquartile range (IQR). The top whisker denotes the maximum value or the 3rd quartile plus 1.5 times the IQR, whichever is smaller. The bottom whisker denotes either the minimum value or the 1st quartile minus 1.5 times the IQR, whichever is larger. Points outside of this range are considered outliers from the distribution of a given boxplot. Generally, boxplots with similar medians and considerable overlap in boxes generally contain similar distributions in values.

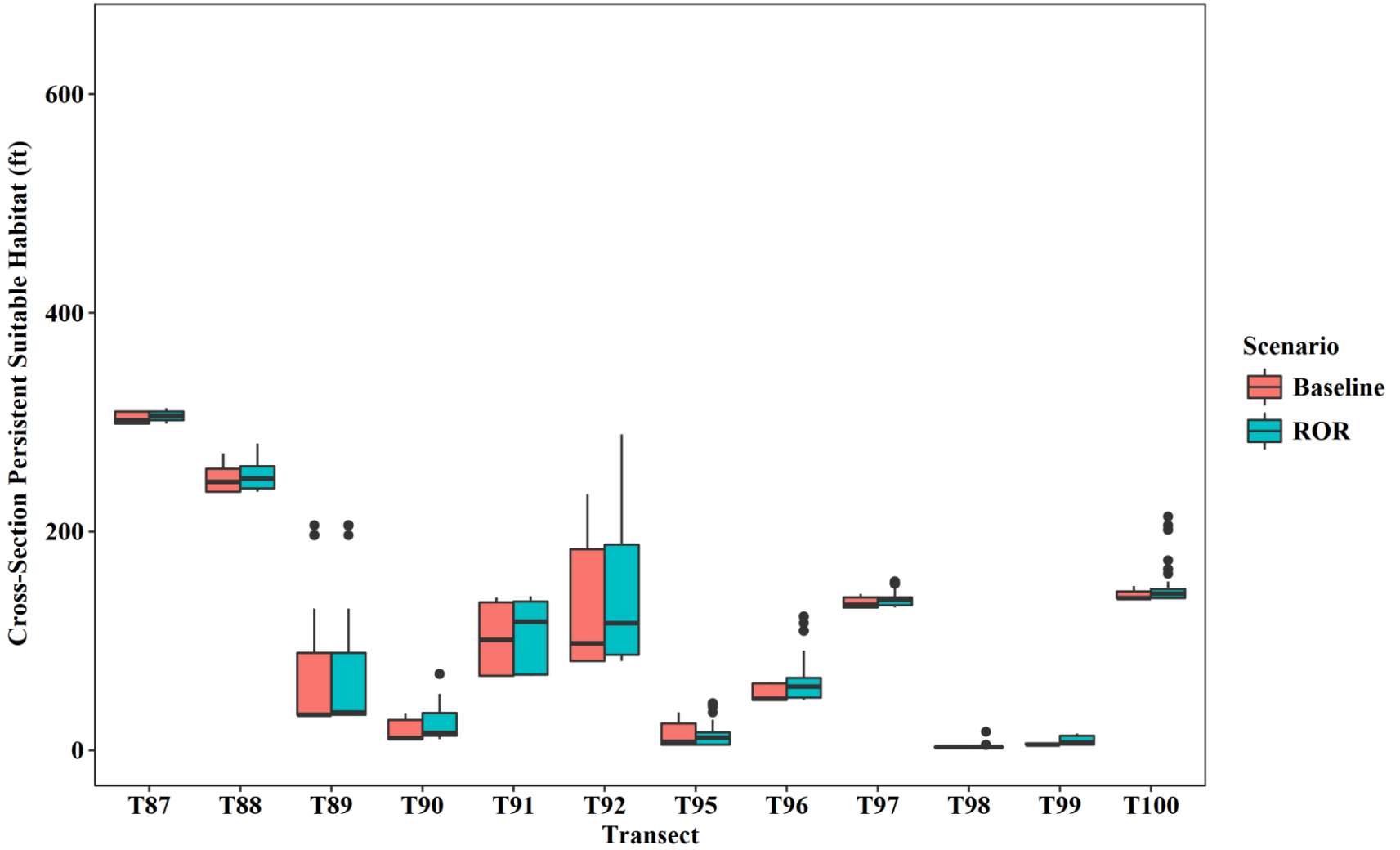


Figure 3.1-1: Persistent Habitat for 40 Juvenile Yellow Lampmussel 2-Year Cohorts (1962 through 2003) at Transects in Reach 4.

Note: Transects are plotted from downstream (left) to upstream (right).

3.2 Adult Yellow Lampmussel

Habitat time series data were developed for adult Yellow Lampmussel using flow time series data from 1962 through 2003 (from the operations model). The amount and location of habitat was calculated for each year, for a total of 42 years. Spatially, the amount of adult Yellow Lampmussel habitat in Reach 4 that persisted each year varied considerably among transects (Figure 3.2-1). Baseline conditions typically provided similar to slightly lower median amounts of persistent habitat than ROR conditions. With the exception of outlier years, the baseline conditions also resulted in very little variability among years; at some transects, especially those near the upper end of Reach 4, ROR conditions provided a wider range of annual persistent habitat variability. Detailed information regarding the locations of persistent habitat at each transect for all years in the time series are shown in Appendix B.

The transects with the greatest amounts of adult Yellow Lampmussel habitat were located in the upstream portions of the reach. The amount of adult persistent habitat was similar to or higher than the amount observed for juvenile mussel cohorts, with considerably more persistent habitat than for juveniles from T96 through T100. At these transects, adult persistent habitat was present in many areas of the channel where there was no juvenile persistent habitat available for any of the cohorts (see pages C9-C13 of Appendix C and D9-D13 of Appendix D for a comparison of juvenile and adult habitat for Baseline and ROR conditions, respectively). Alternatively, transects T87 and T88, which had the highest amounts of juvenile persistent habitat, contained relatively similar amounts and cross-sectional distributions when comparing adult and juvenile persistent habitat for both Baseline and ROR conditions (see pages C2-C3 of Appendix C and D2-D3 of Appendix D).

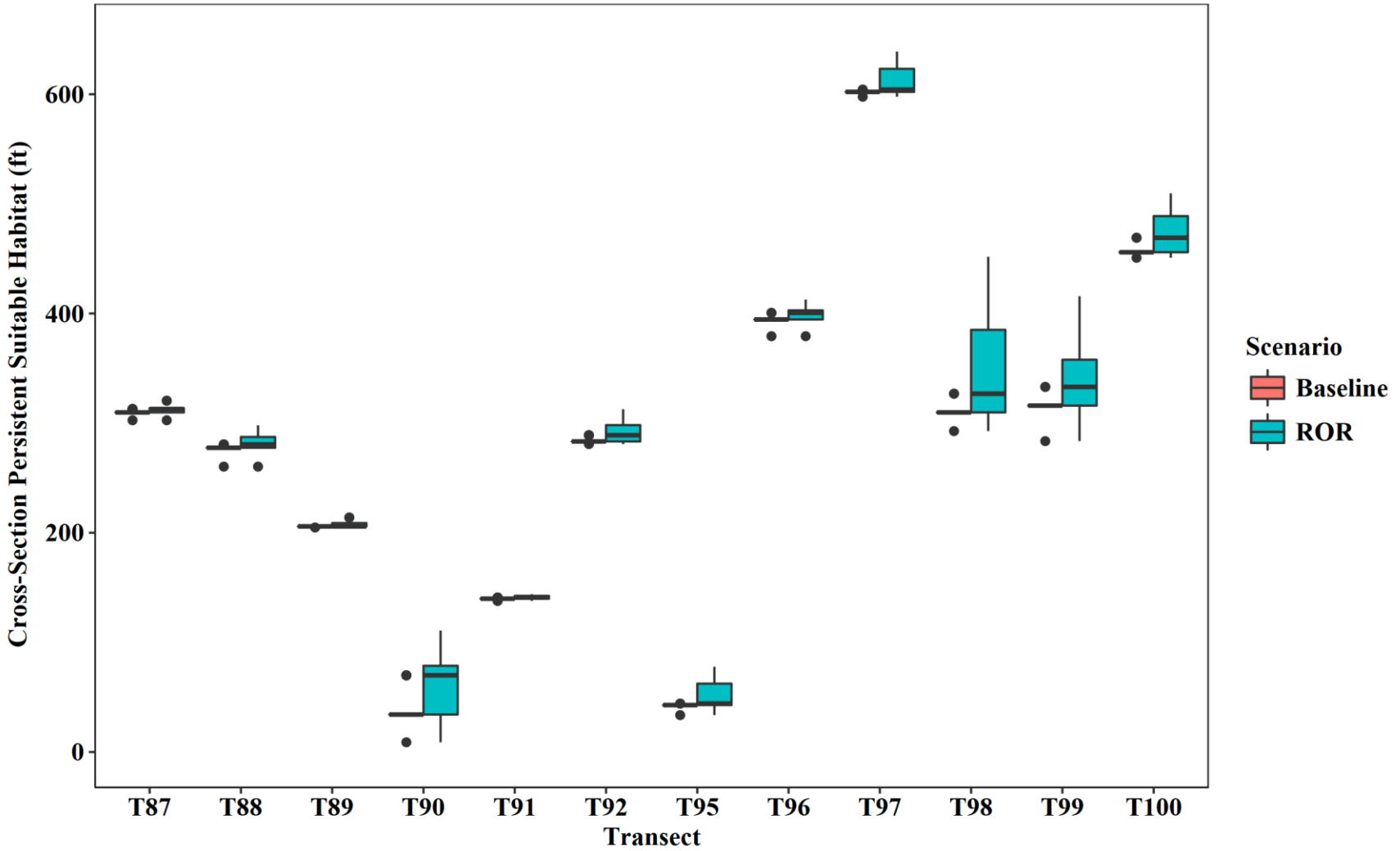


Figure 3.2-1: Persistent Habitat for Adult Yellow Lampmussel for the Years 1962 through 2003 at Transects in Reach 4.

Note: Transects are plotted from downstream (left) to upstream (right).

3.3 Sea Lamprey Spawning

Habitat time series data were developed for 42 spawning Sea Lamprey cohorts using flow time series data from 1962 through 2003 (from the operations model) during the Sea Lamprey spawning period (May 20 through July 31). No transects in Reach 4 contained persistent habitat for Sea Lamprey spawning during baseline or ROR flow conditions (Figure 3.3-1).

The flow duration curves for the May 20 through July 31 Sea Lamprey spawning period, for both baseline and ROR conditions are shown in Figure 3.3-2. These curves show that flows in excess of FL generation capacity (about 16,000 cfs) are common both in the baseline and ROR conditions during the Sea Lamprey spawning period.

3.3.1 Sea Lamprey Spawning Dual Flow Tables

Dual flow tables were developed for flow values provided in Section 2.4. The tables for Total Suitable Habitat and Quality Habitat and the percentages of each are provided in Appendix E. The tables provided results similar to the persistent habitat analysis, in that limited if any persistent habitat, especially quality habitat exists over differing flow ranges.

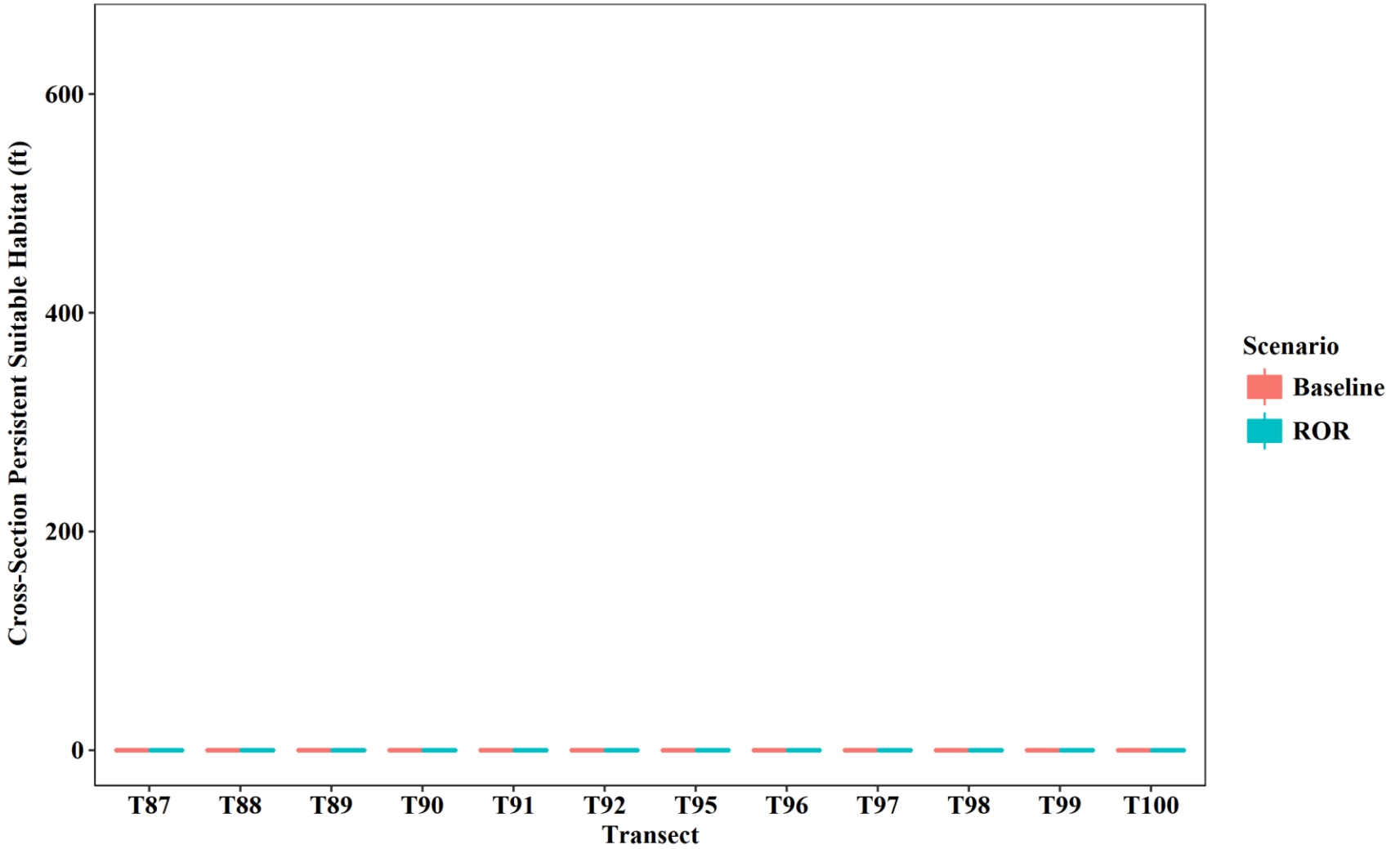


Figure 3.3-1: Persistent Habitat for 42 Spawning Sea Lamprey Cohorts (May 20 through July 31, 1962 through 2003) at Transects in Reach 4.

Note: Transects are plotted from downstream (left) to upstream (right).

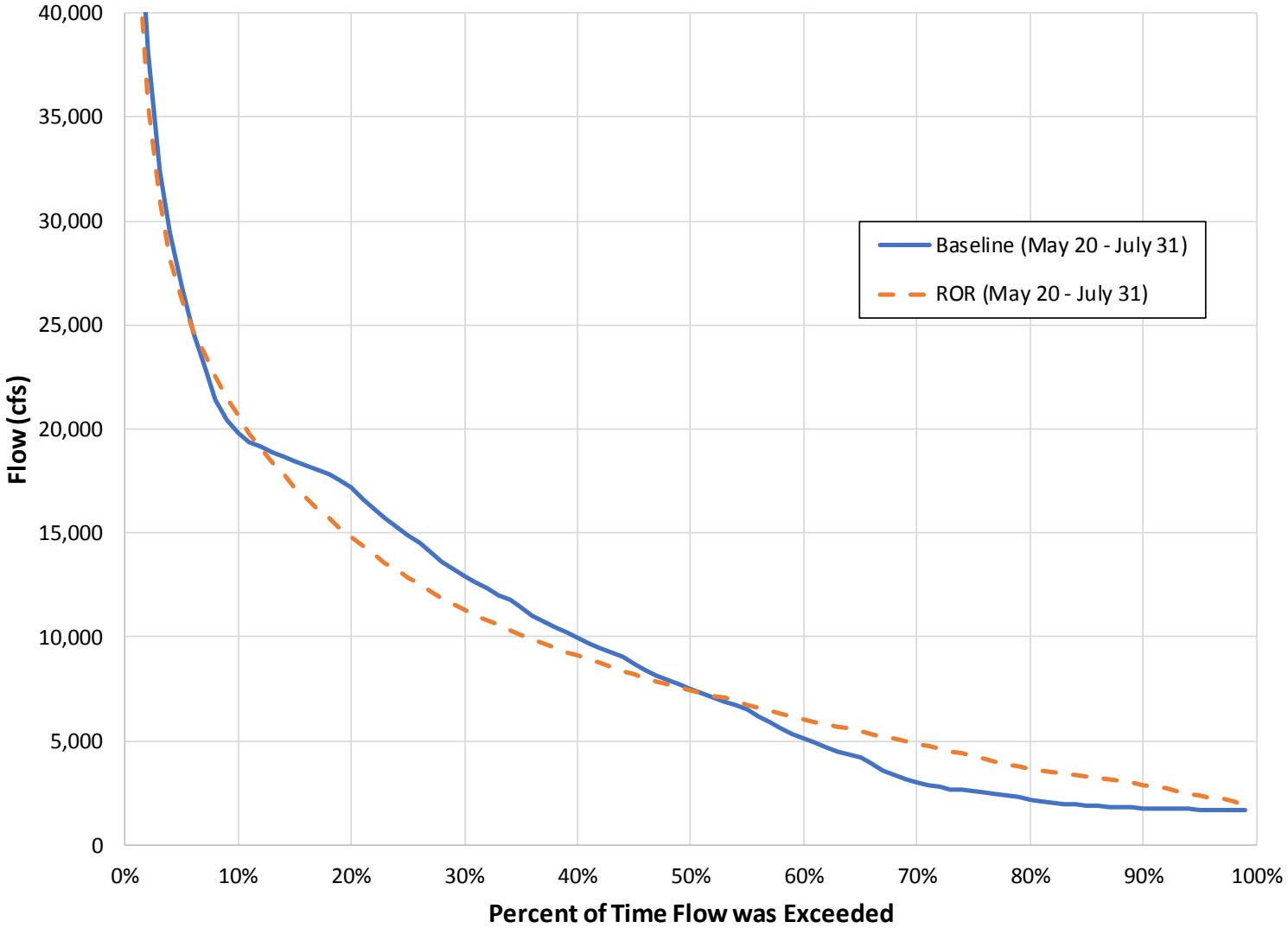


Figure 3.3-2: Modeled Hourly Montague Flow (1962-2003) Duration Curves for May 20 – July 31

4 DISCUSSION

4.1 Yellow Lampmussel

Though providing ROR conditions could provide slightly more adult Yellow Lampmussel persistent habitat during some years at most of the transects, the limiting factor for habitat in Reach 4 is the juvenile life stage. There appears to be a spatial disconnect of persistent habitat between adult and juvenile Yellow Lampmussel in Reach 4, given that the areas with the greatest amount of adult habitat provide very small amounts of juvenile persistent habitat. The transects with the most persistent suitable habitat were located near Second Island, with T87 at the downstream end of the island and T88 bisecting the island. These areas contain the most habitat where Yellow Lampmussel may colonize as juveniles, where they could then persist as adults; these findings are consistent with the results of the mussel survey performed in 2014 for Study 3.3.16 – *Habitat Assessment, Surveys, and Modeling for State-Listed Mussel Species in the Connecticut River below Cabot Station*, which found a single relic Yellow Lampmussel shell near these transects, but none elsewhere within the reach. The areas around Second Island where the mussel surveys were performed could be characterized as a relatively large sandbar area. Large sandbar habitats are considered high-quality habitat for this species, and these types of areas are found in greater size and frequency in the downstream portions of Reach 5 than in Reach 4.

Though some suitable habitat for Yellow Lampmussels is present within the reach, providing ROR flow conditions as opposed to baseline flow conditions at the Turners Falls Project would not increase the amount of persistent habitat available for juvenile Yellow Lampmussels within Reach 4. Any benefits that ROR flows could provide to adult Yellow Lampmussel in some areas would be mitigated by considerably lower amounts of juvenile habitat in those areas (Figure 4.1-1). As such, providing ROR flow conditions will not provide benefits for this species in Reach 4.

4.2 Sea Lamprey Spawning

Though some habitat appears to be suitable during some steady state flow conditions within Reach 4, habitat shifts with flow result in no persistent habitat over the span of a spawning season. Habitat time series analysis suggests that Reach 4 lacked persistent spawning habitat for Sea Lamprey for all years evaluated. This is consistent with the results of radio telemetry studies that tracked Sea Lamprey further upstream and into tributaries, but none were observed stopping to build redds in Reach 4 (see Relicensing Study Report for Study 3.3.15 - *Assessment of Adult Sea Lamprey Spawning within the Turners Falls Project and Northfield Mountain Project Area* – June 2016). Based on the time series analysis, providing ROR conditions would not increase the amount of persistent habitat available for Sea Lamprey spawning in Reach 4.

Similar to the persistent habitat time series analysis, the dual flow tables indicate a lack of habitat, especially quality habitat, during the spawning period. This lack of habitat is largely due to narrow ranges in flow where habitat suitability at specific locations is persistent. This range becomes narrower at higher flow rates, and even naturalized river flow conditions would not provide the flow stability necessary to provide persistent habitat for Sea Lamprey spawning.

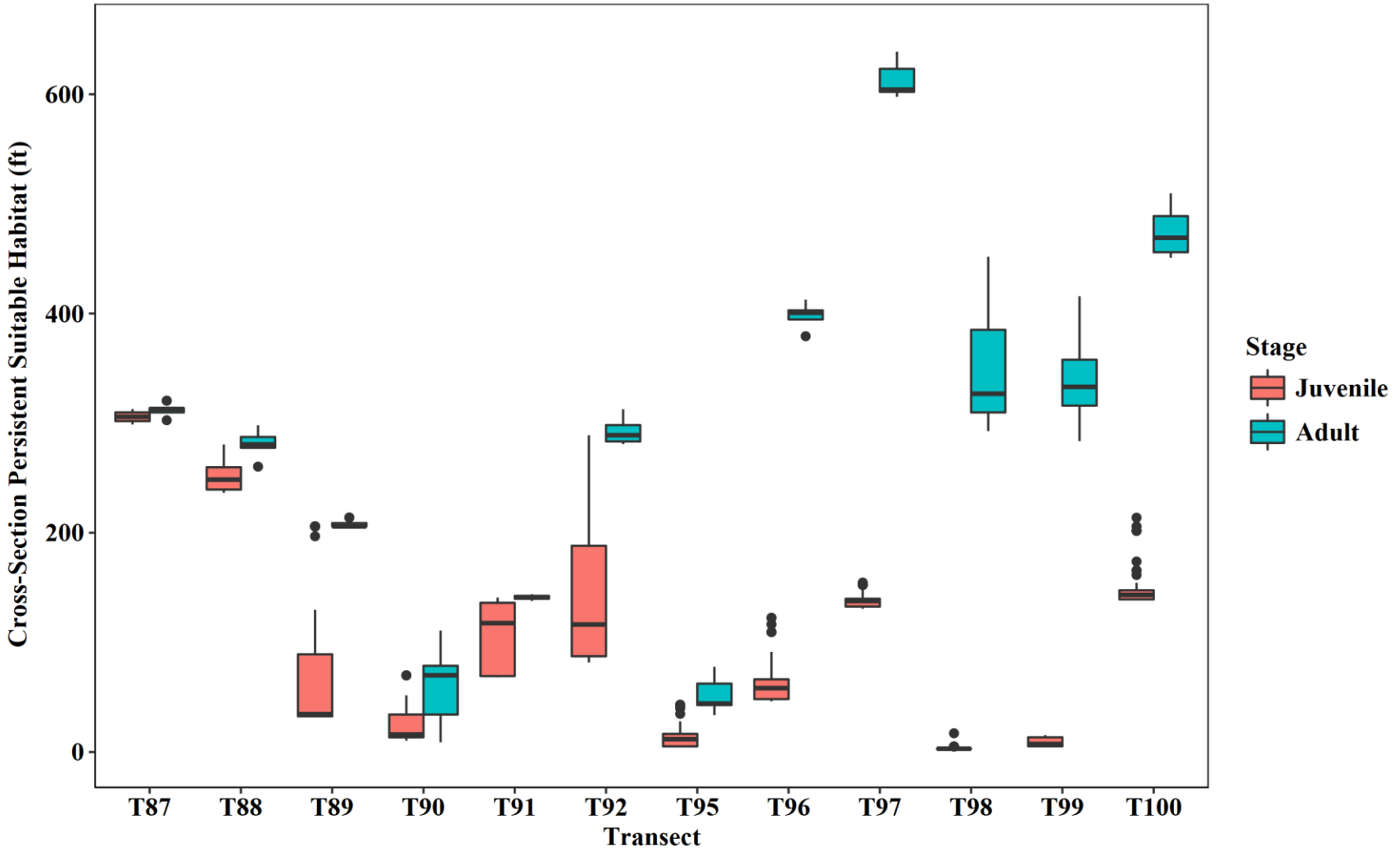


Figure 4.1-1: Persistent Habitat Available to Juvenile Yellow Lampmussel 2-Year Cohorts and Adult Yellow Lampmussel during the Years 1962 through 2003 based on ROR Flow Conditions at the Turners Falls Project.

APPENDIX A: JUVENILE YELLOW LAMPMUSSEL PERSISTENT HABITAT TRANSECT PLOTS – BASELINE AND ROR COMPARISON

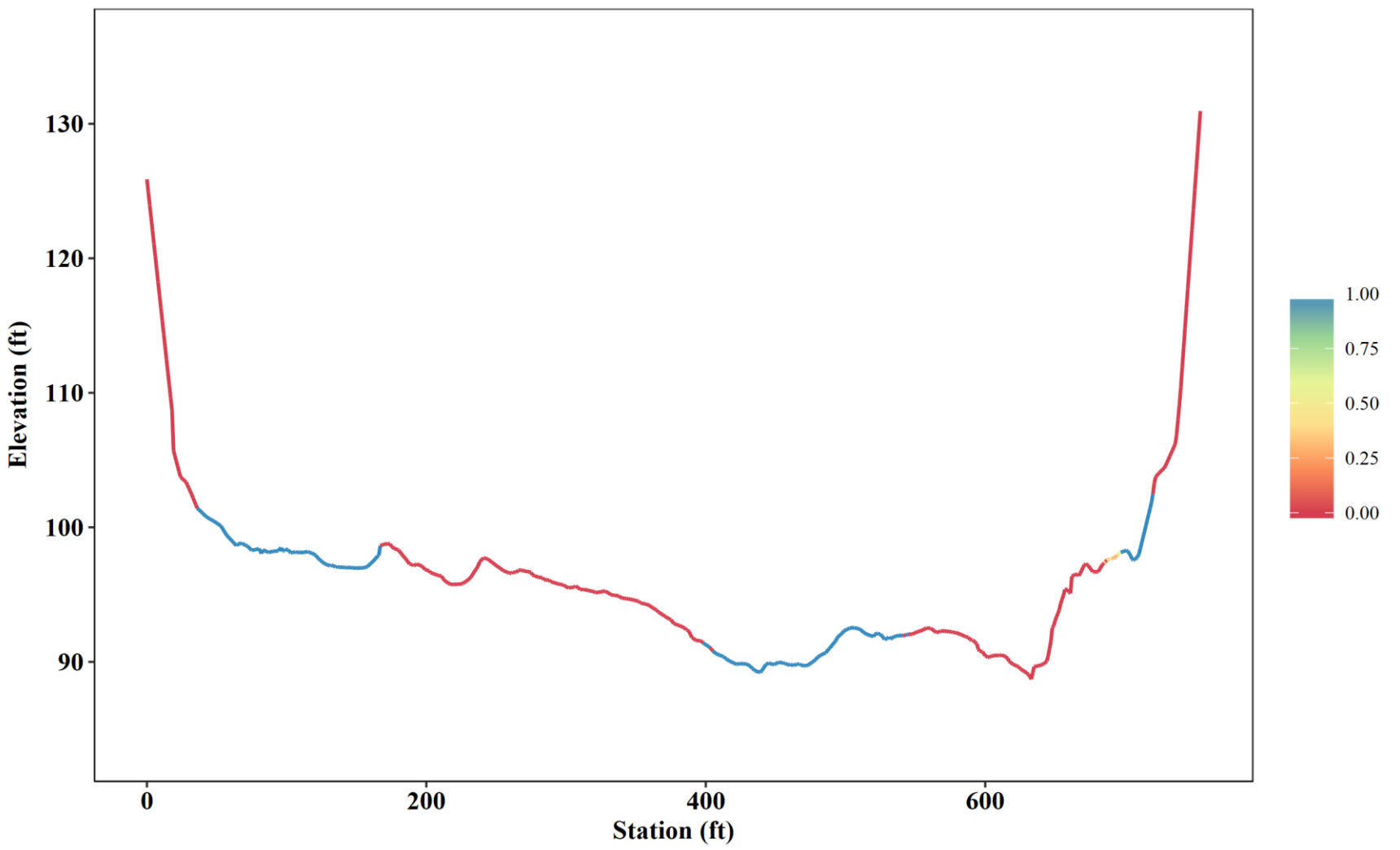


Figure A-1: Persistent Suitable Habitat Available to Proportions of 40 Juvenile Yellow Lampmussel 2-Year Cohorts (1962 through 2003) at T87 during Baseline Operating Conditions.

Note: The colors along the transect profile indicate the proportions of cohorts with persistent habitat available at a given location across the transect.

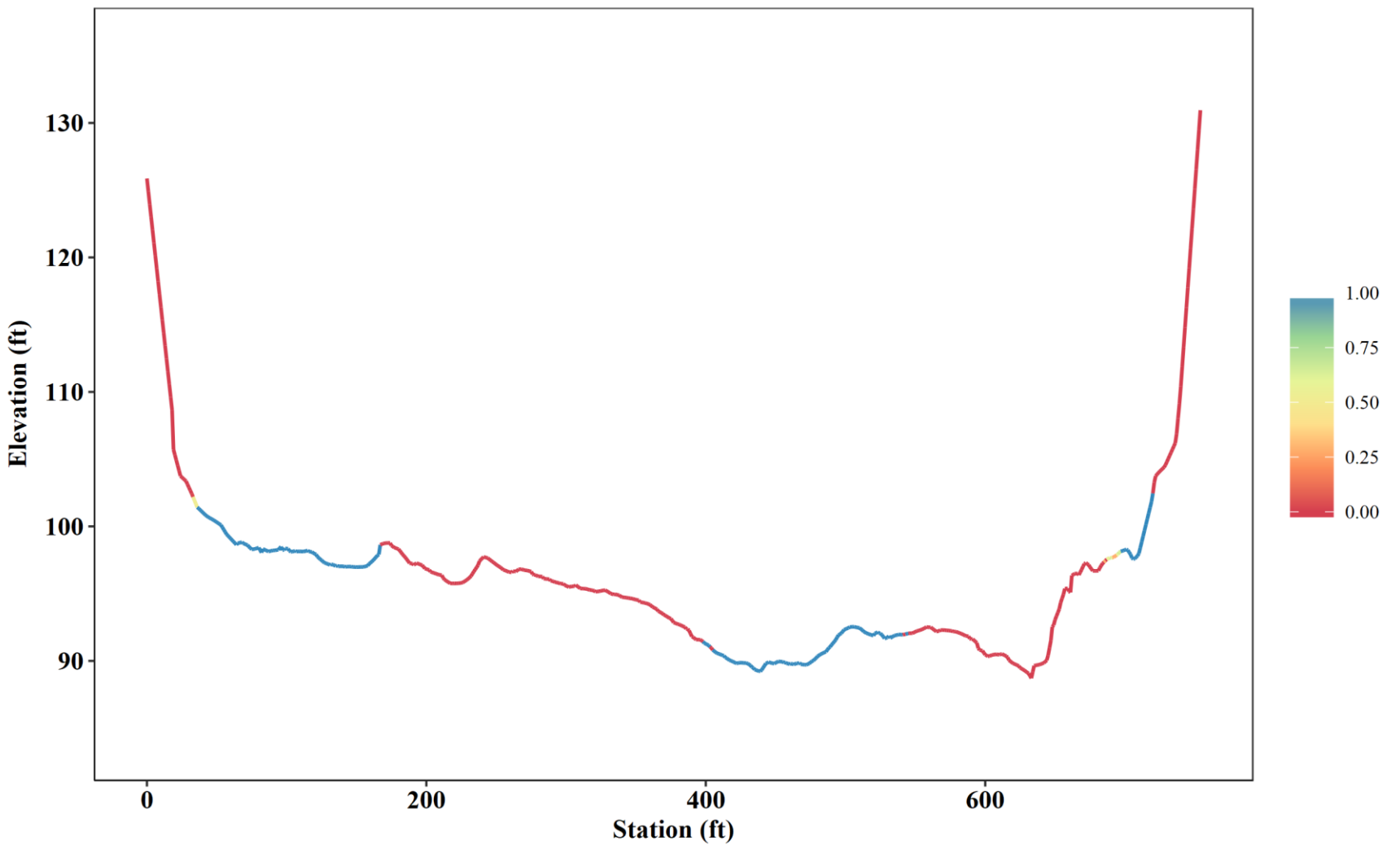


Figure A-2: Persistent Suitable Habitat Available to Proportions of 40 Juvenile Yellow Lampmussel 2-Year Cohorts (1962 through 2003) at T87 during ROR Operating Conditions.

Note: The colors along the transect profile indicate the proportions of cohorts with persistent habitat available at a given location across the transect.

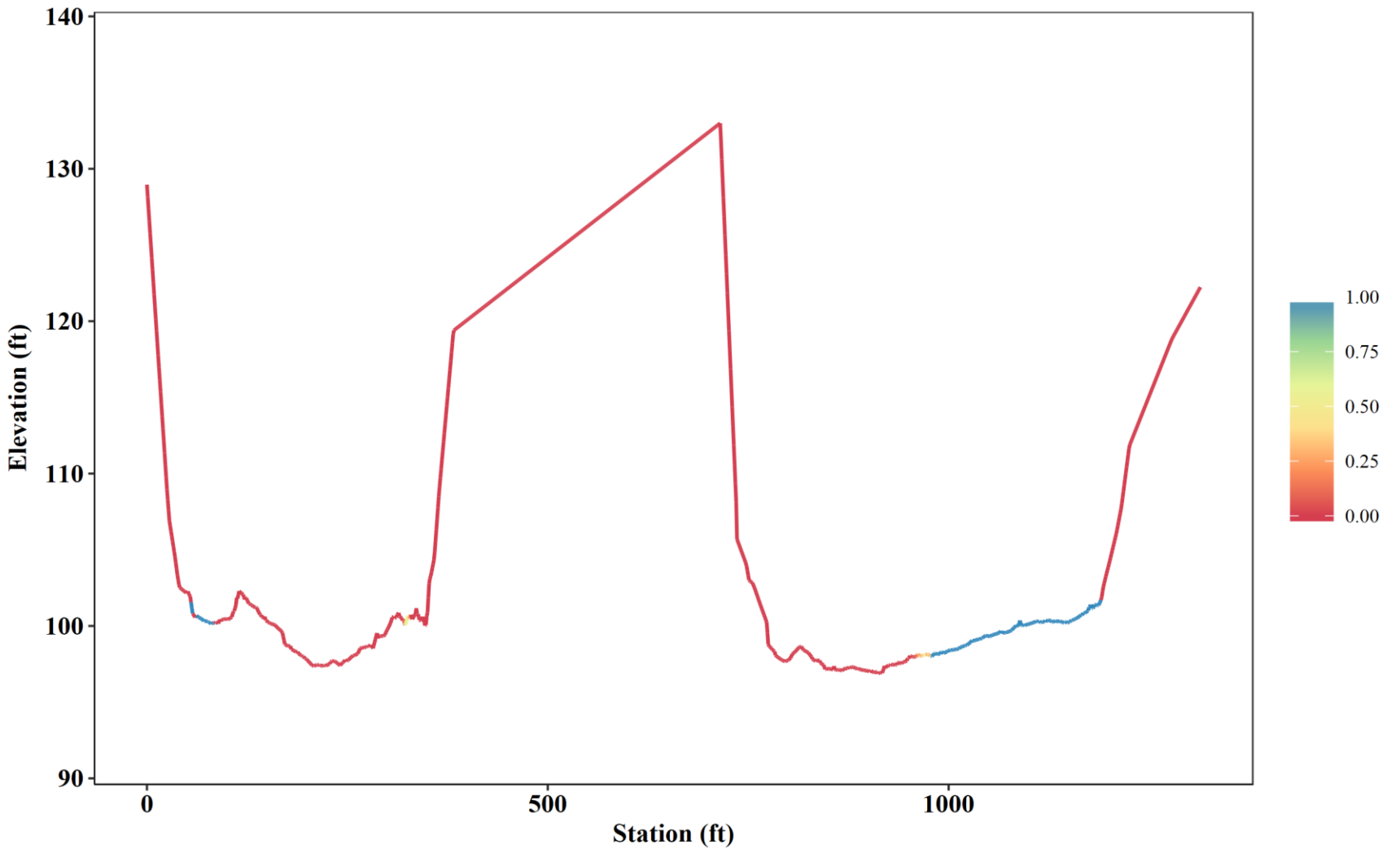


Figure A-3: Persistent Suitable Habitat Available to Proportions of 40 Juvenile Yellow Lampmussel 2-Year Cohorts (1962 through 2003) at T88 during Baseline Operating Conditions.

Note: The colors along the transect profile indicate the proportions of cohorts with persistent habitat available at a given location across the transect.

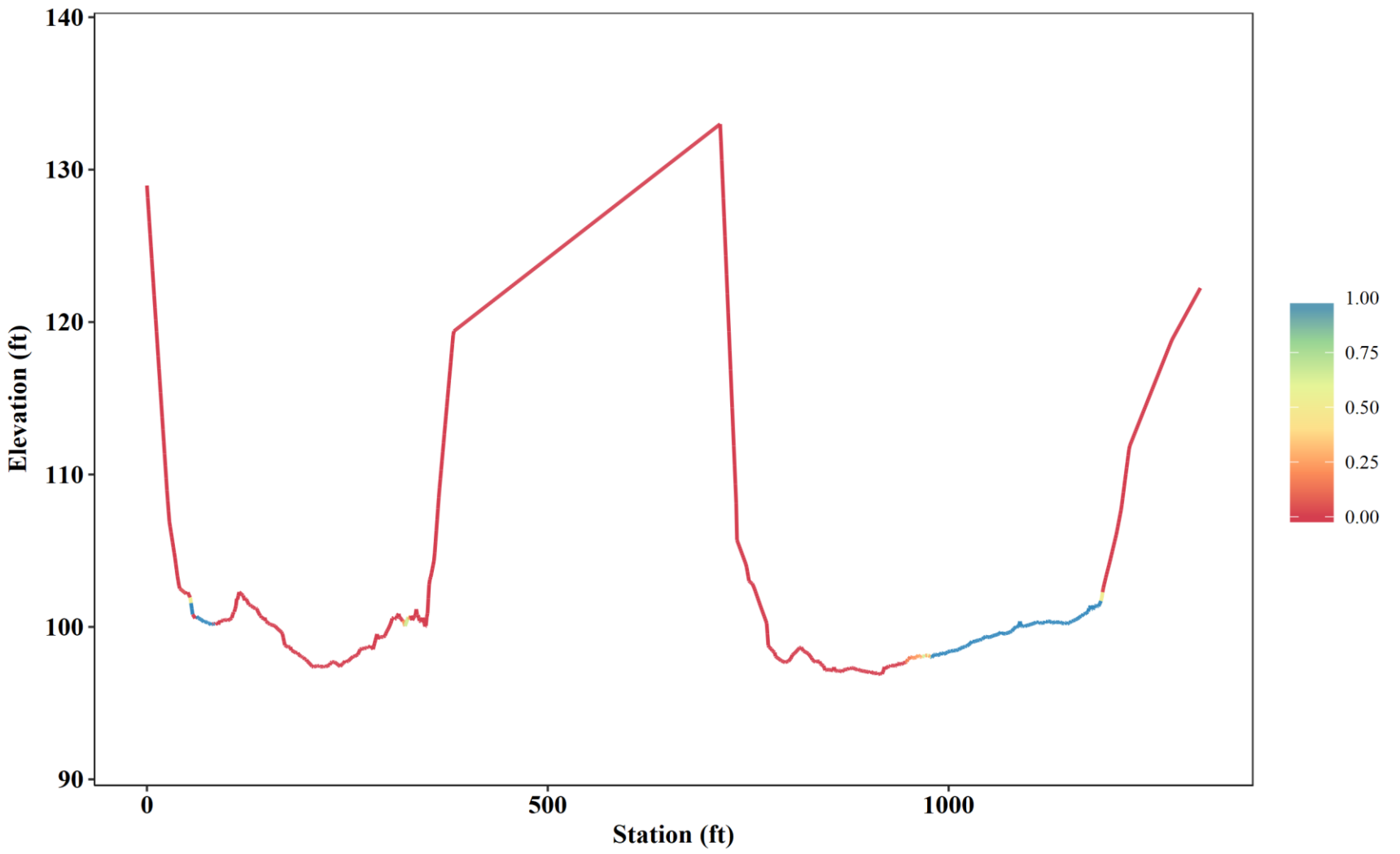


Figure A-4: Persistent Suitable Habitat Available to Proportions of 40 Juvenile Yellow Lampmussel 2-Year Cohorts (1962 through 2003) at T88 during ROR Operating Conditions.

Note: The colors along the transect profile indicate the proportions of cohorts with persistent habitat available at a given location across the transect.

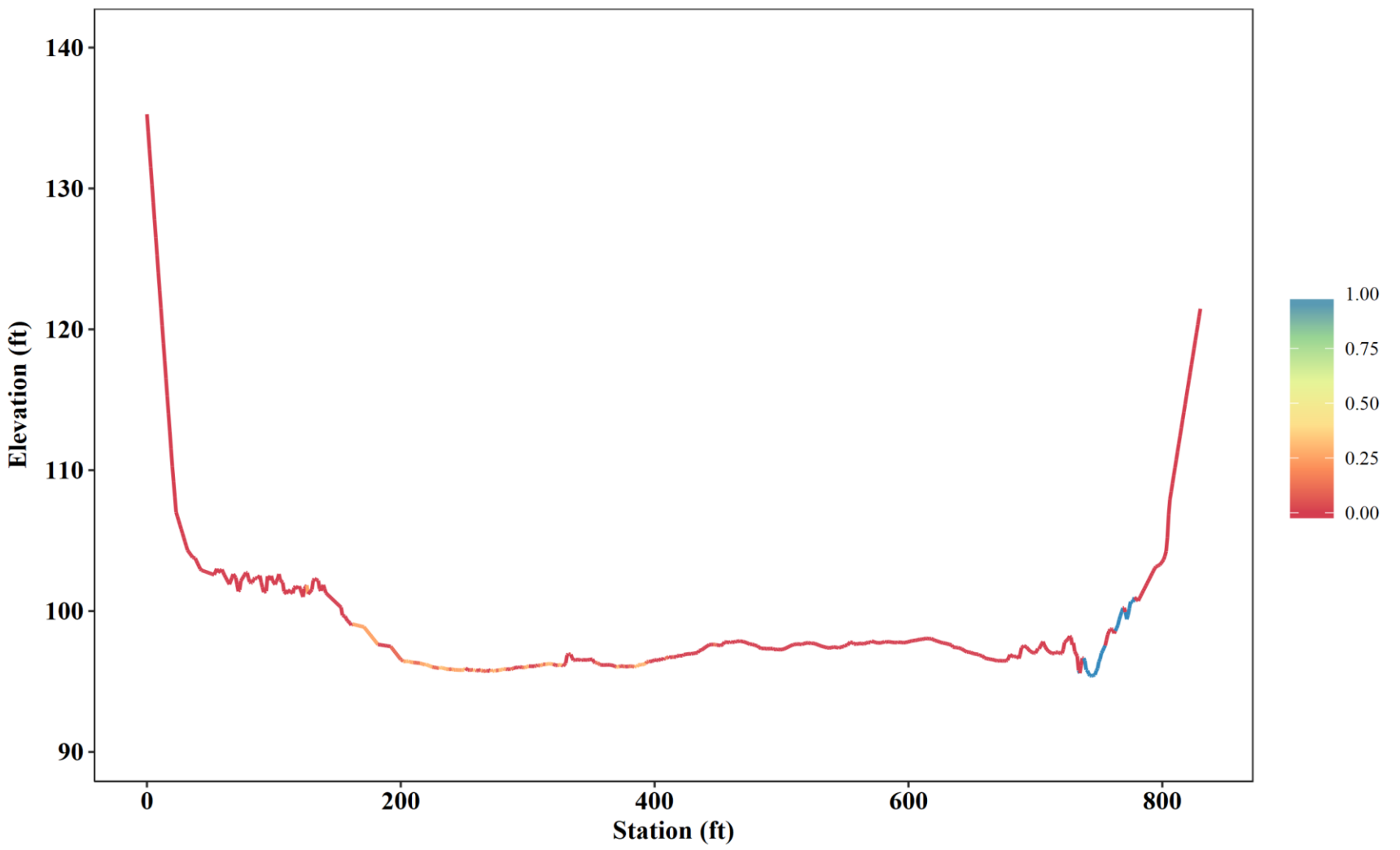


Figure A-5: Persistent Suitable Habitat Available to Proportions of 40 Juvenile Yellow Lampmussel 2-Year Cohorts (1962 through 2003) at T89 during Baseline Operating Conditions.

Note: The colors along the transect profile indicate the proportions of cohorts with persistent habitat available at a given location across the transect.

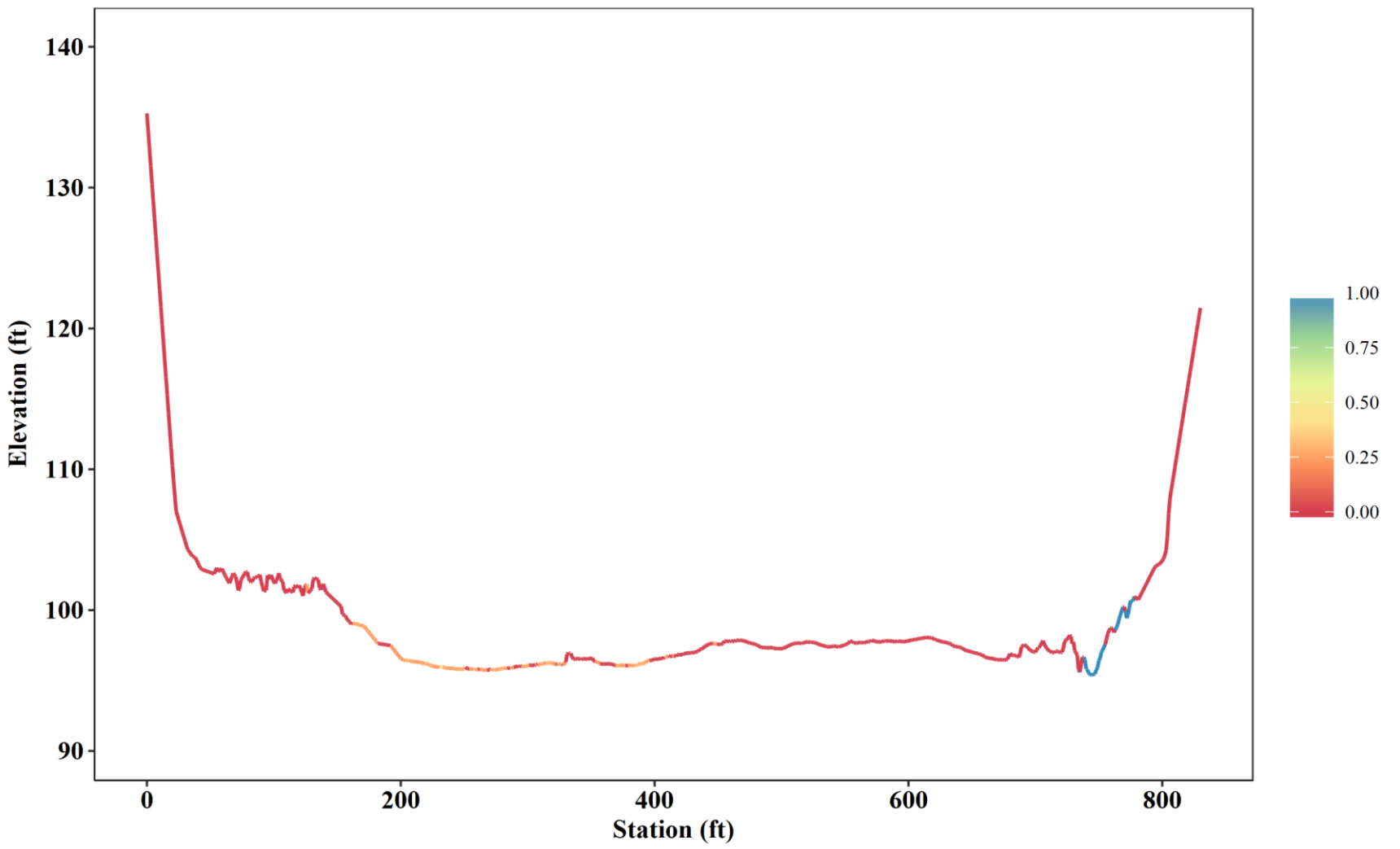


Figure A-6: Persistent Suitable Habitat Available to Proportions of 40 Juvenile Yellow Lampmussel 2-Year Cohorts (1962 through 2003) at T89 during ROR Operating Conditions.

Note: The colors along the transect profile indicate the proportions of cohorts with persistent habitat available at a given location across the transect.

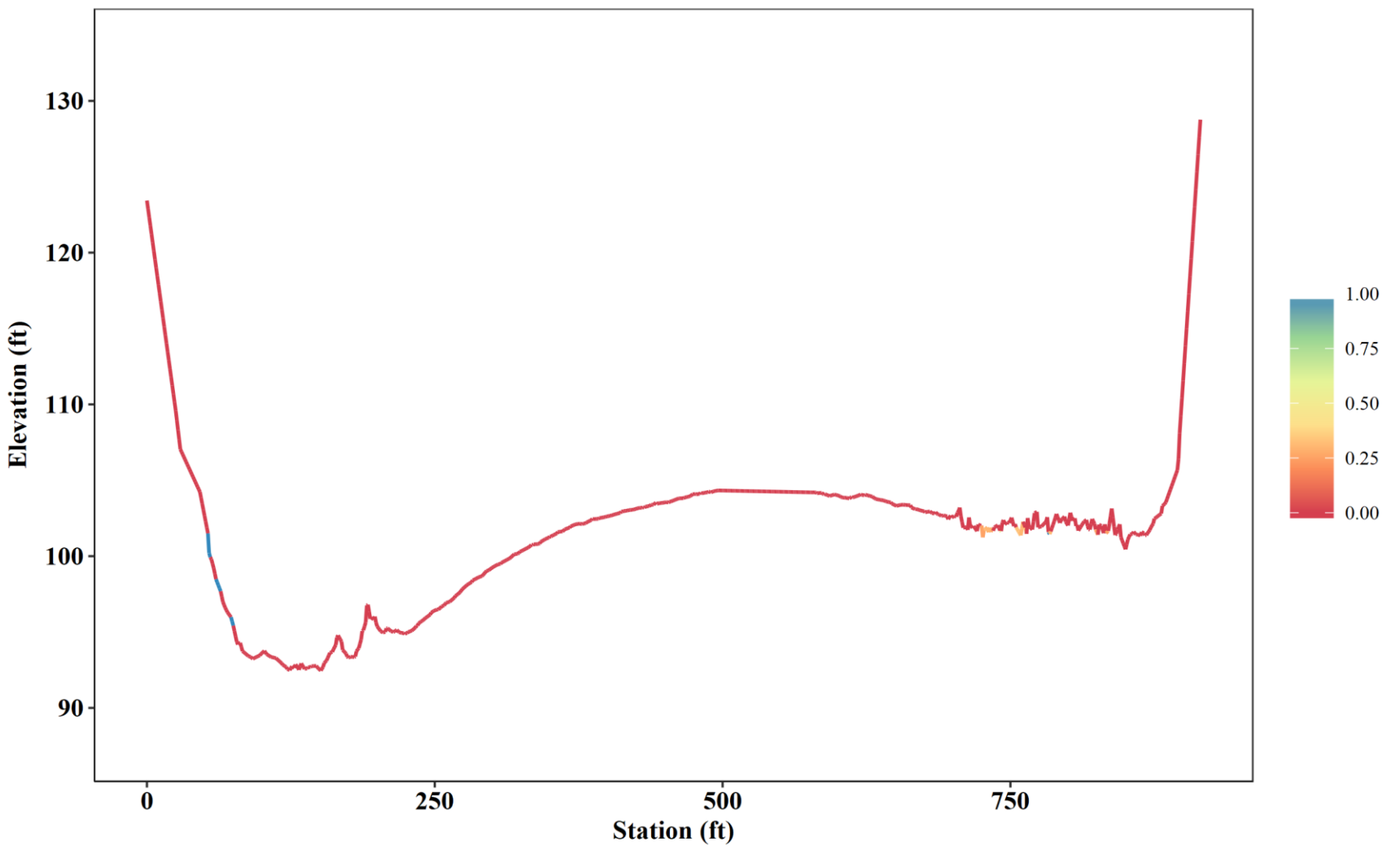


Figure A-7: Persistent Suitable Habitat Available to Proportions of 40 Juvenile Yellow Lampmussel 2-Year Cohorts (1962 through 2003) at T90 during Baseline Operating Conditions.

Note: The colors along the transect profile indicate the proportions of cohorts with persistent habitat available at a given location across the transect.

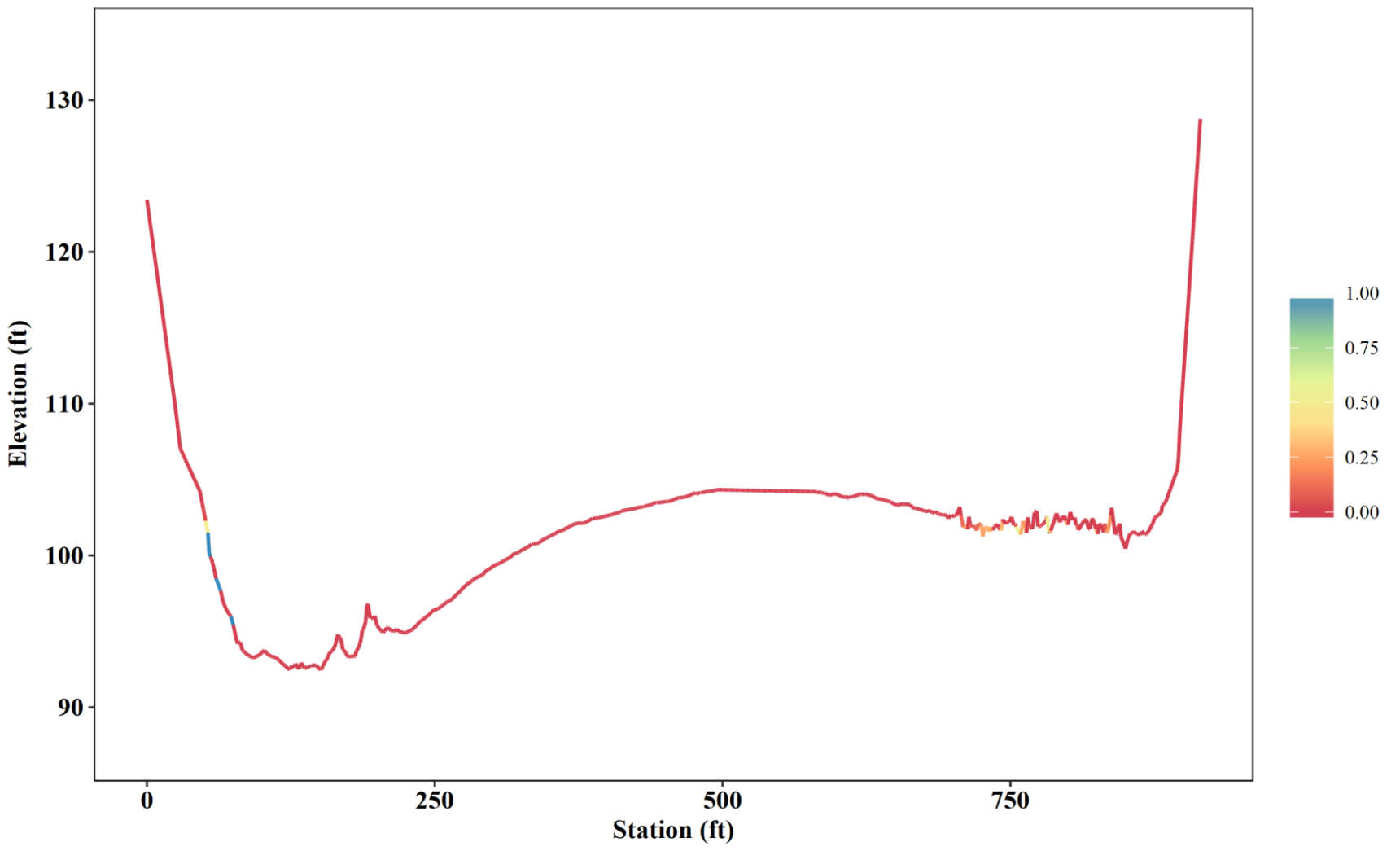


Figure A-8: Persistent Suitable Habitat Available to Proportions of 40 Juvenile Yellow Lampmussel 2-Year Cohorts (1962 through 2003) at T90 during ROR Operating Conditions.

Note: The colors along the transect profile indicate the proportions of cohorts with persistent habitat available at a given location across the transect.

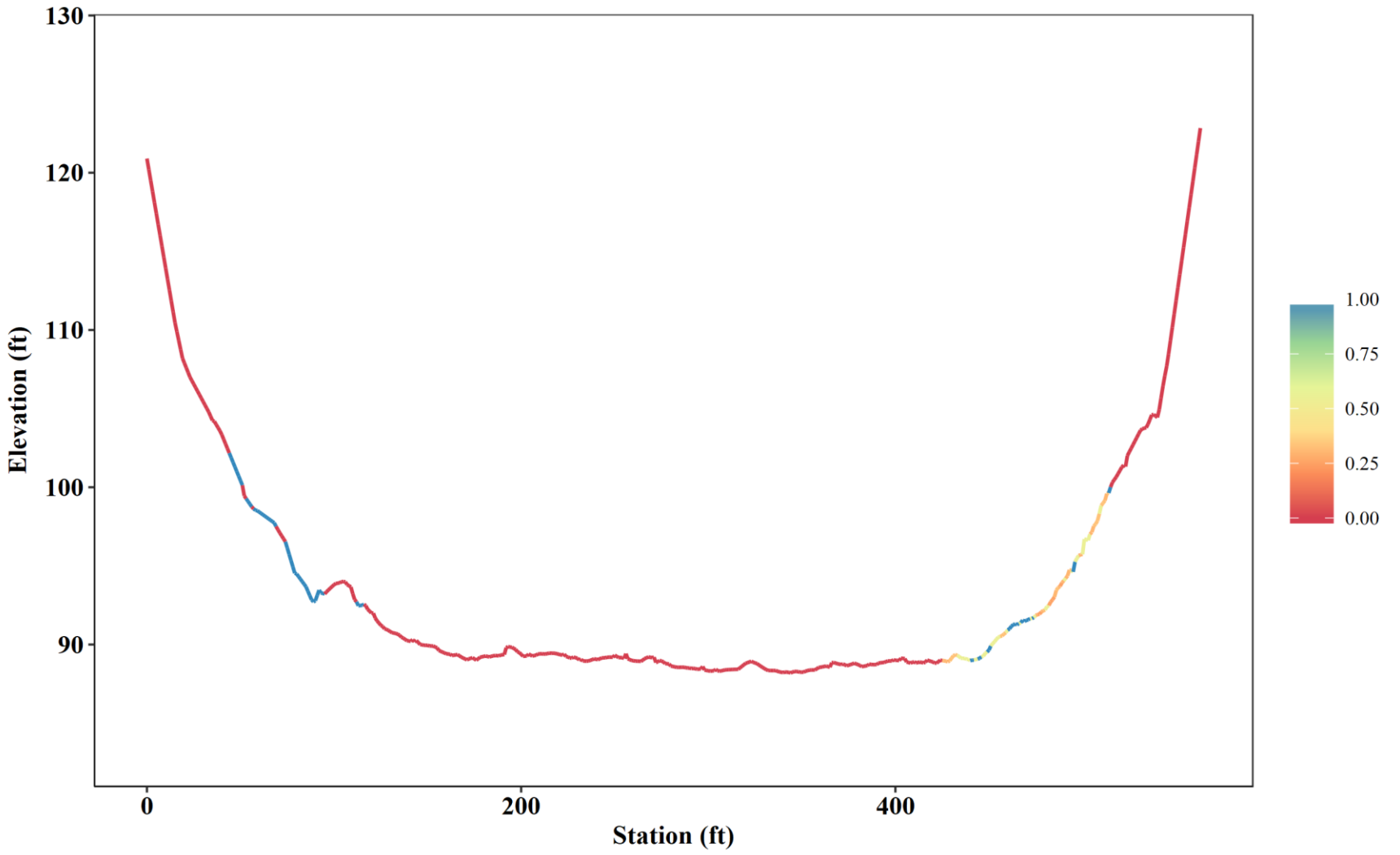


Figure A-9: Persistent Suitable Habitat Available to Proportions of 40 Juvenile Yellow Lampmussel 2-Year Cohorts (1962 through 2003) at T91 during Baseline Operating Conditions.

Note: The colors along the transect profile indicate the proportions of cohorts with persistent habitat available at a given location across the transect.

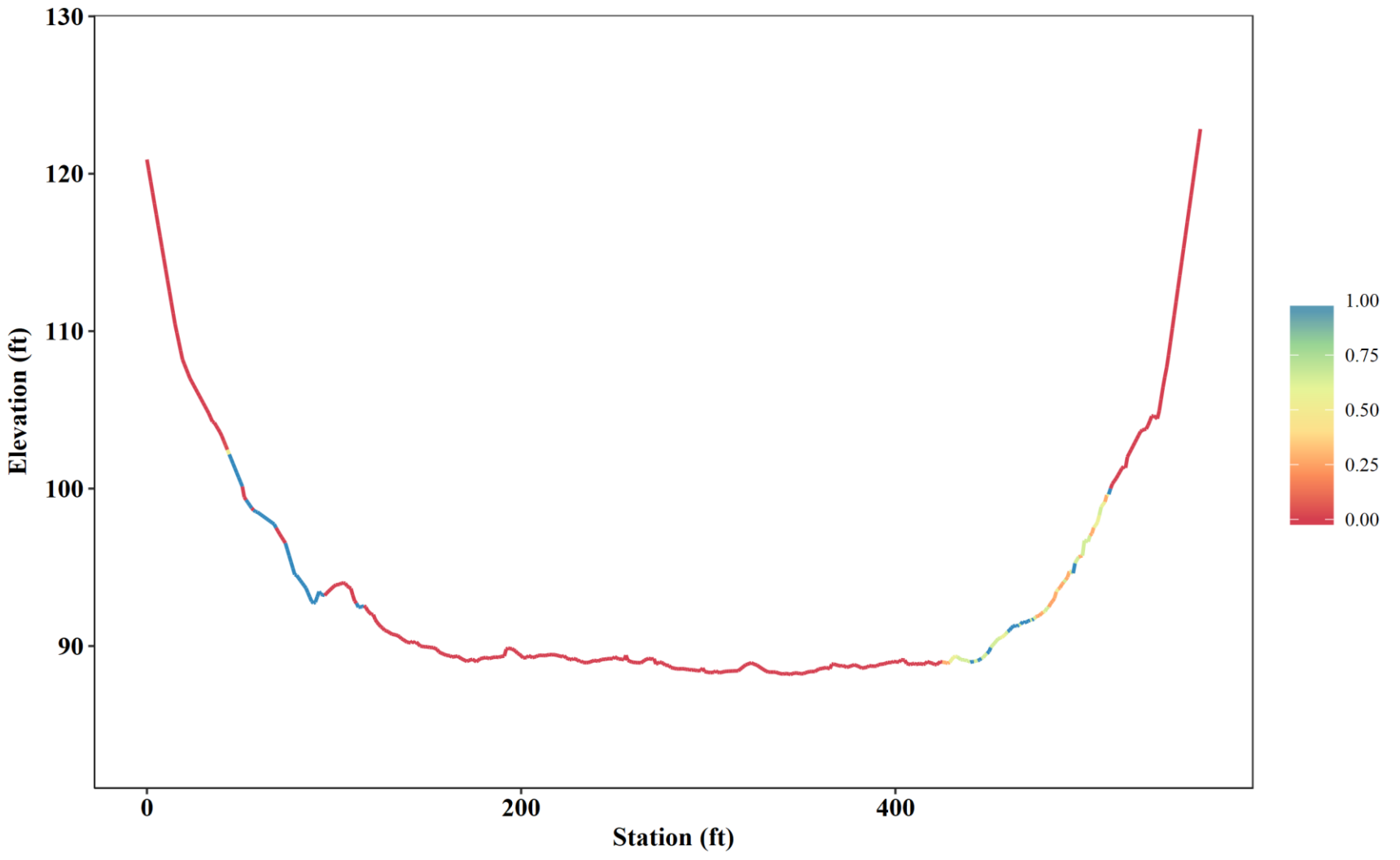


Figure A-10: Persistent Suitable Habitat Available to Proportions of 40 Juvenile Yellow Lampmussel 2-Year Cohorts (1962 through 2003) at T91 during ROR Operating Conditions.

Note: The colors along the transect profile indicate the proportions of cohorts with persistent habitat available at a given location across the transect.

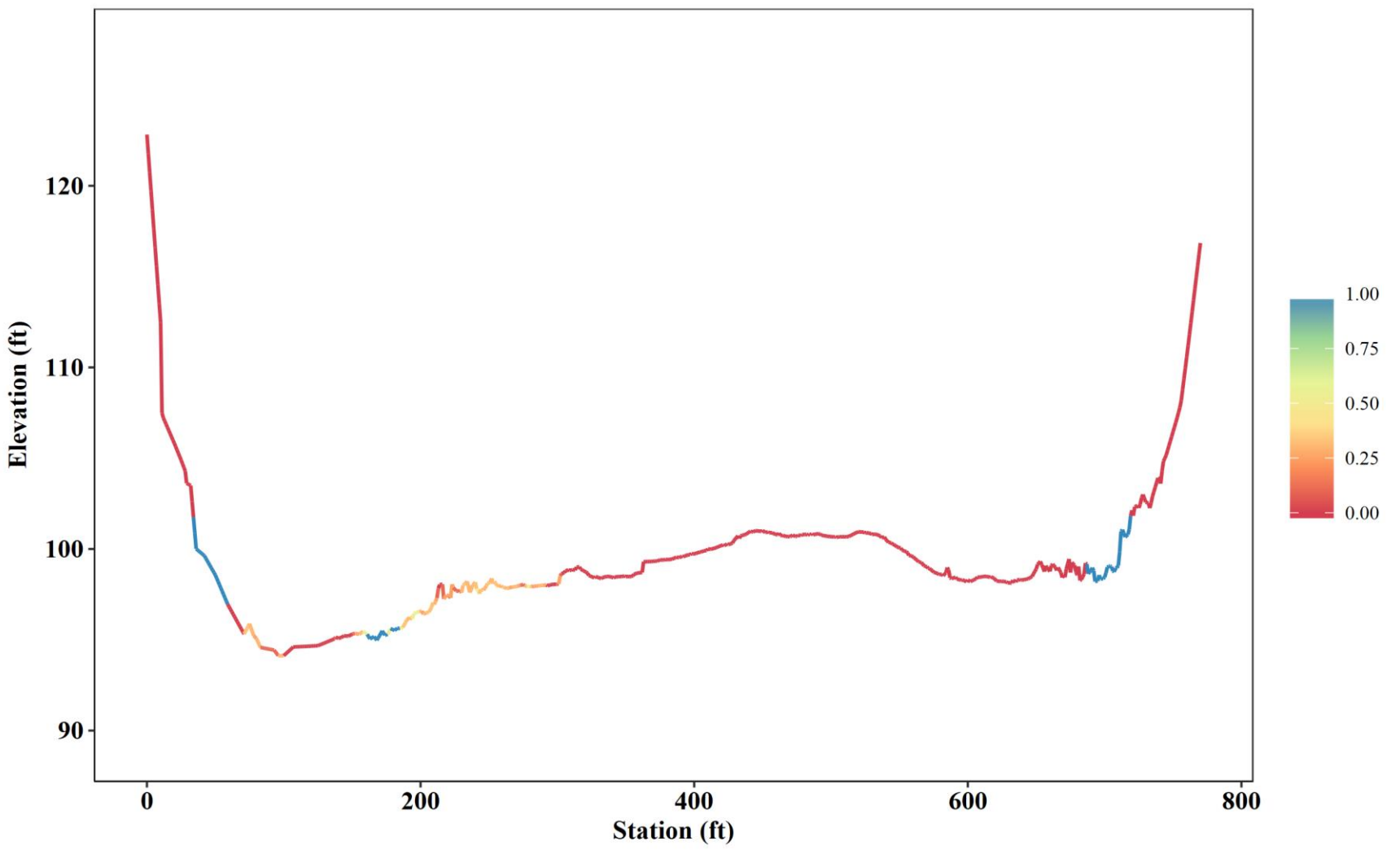


Figure A-11: Persistent Suitable Habitat Available to Proportions of 40 Juvenile Yellow Lampmussel 2-Year Cohorts (1962 through 2003) at T92 during Baseline Operating Conditions.

Note: The colors along the transect profile indicate the proportions of cohorts with persistent habitat available at a given location across the transect.

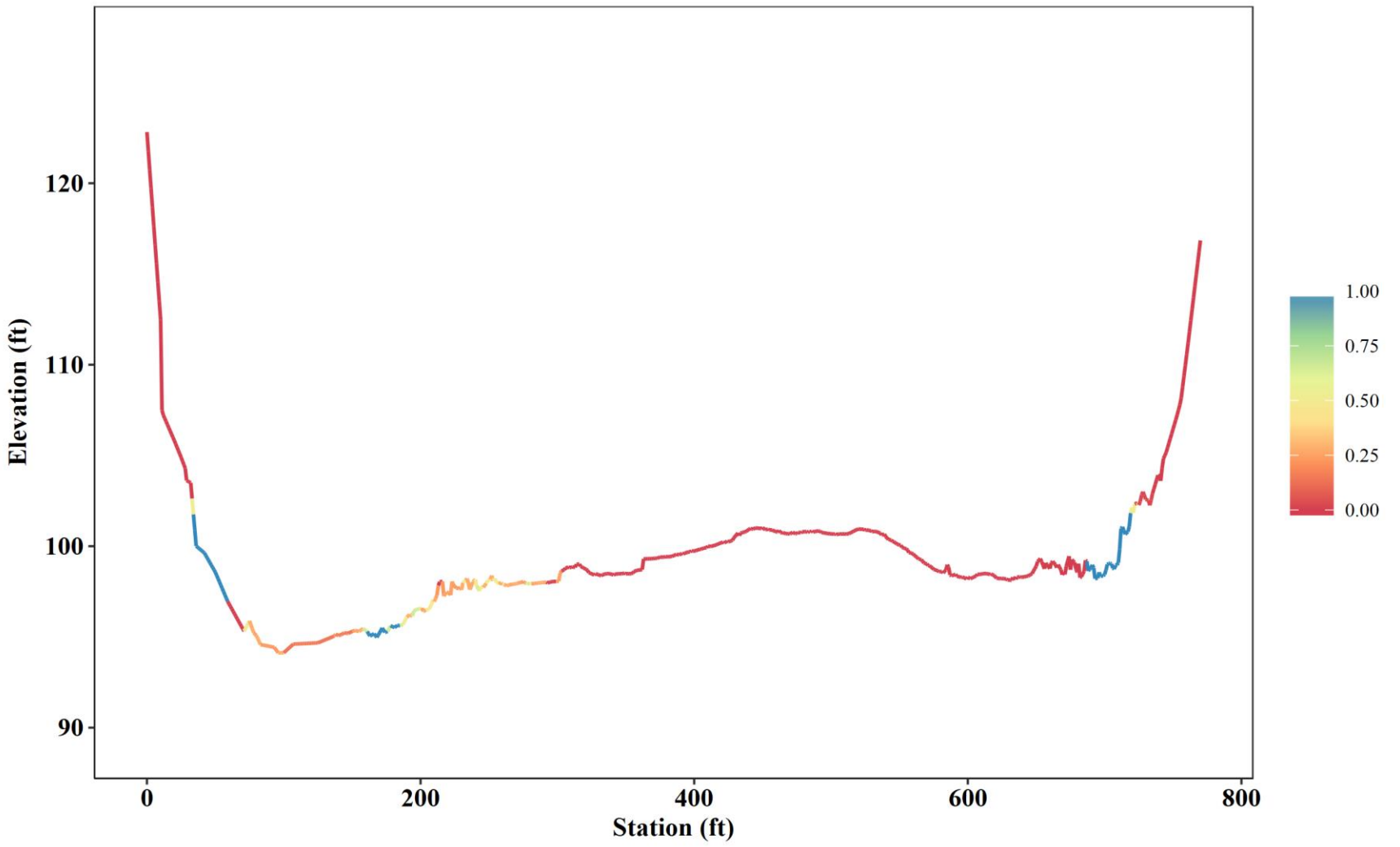


Figure A-12: Persistent Suitable Habitat Available to Proportions of 40 Juvenile Yellow Lampmussel 2-Year Cohorts (1962 through 2003) at T92 during ROR Operating Conditions.

Note: The colors along the transect profile indicate the proportions of cohorts with persistent habitat available at a given location across the transect.

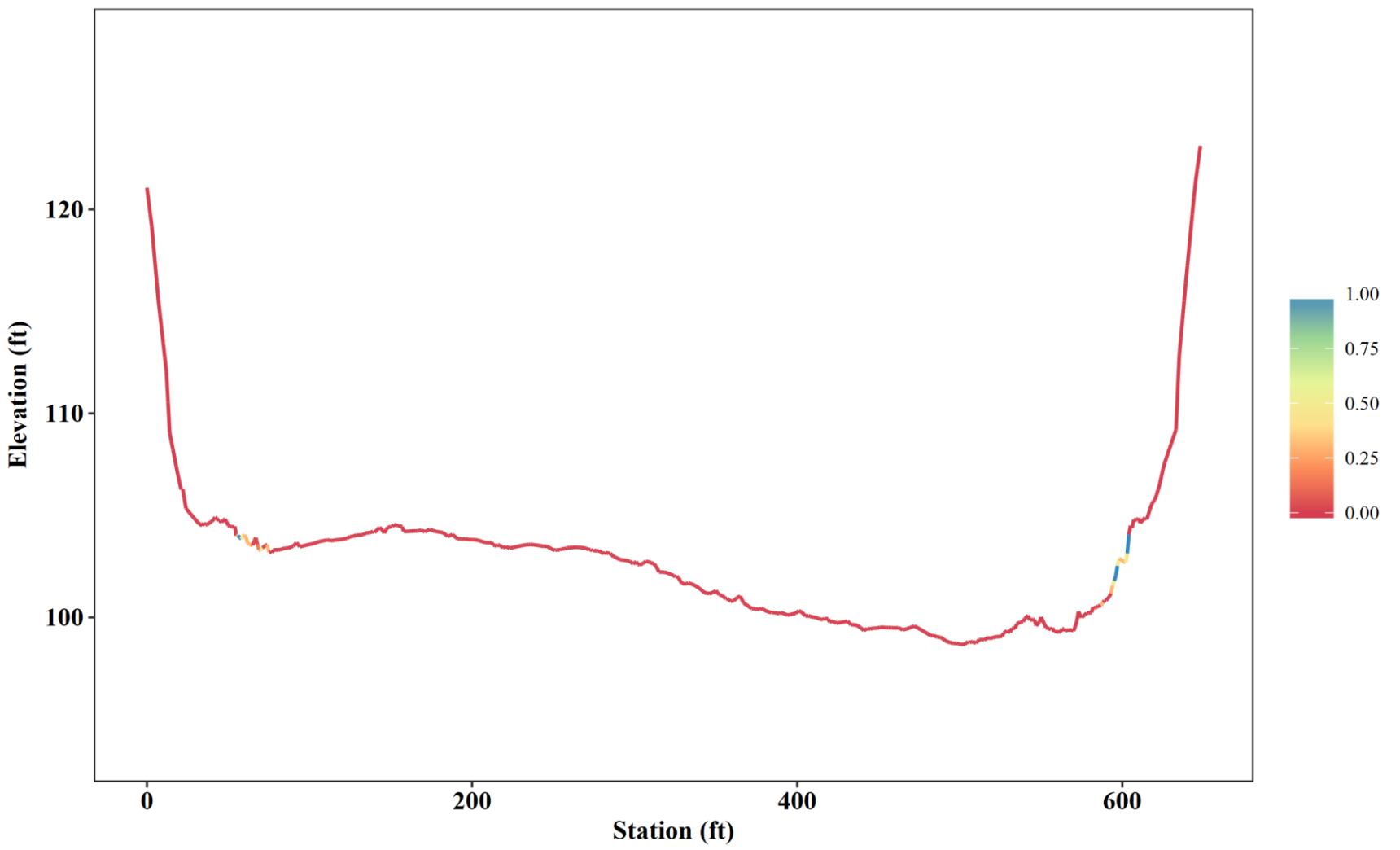


Figure A-13: Persistent Suitable Habitat Available to Proportions of 40 Juvenile Yellow Lampmussel 2-Year Cohorts (1962 through 2003) at T95 during Baseline Operating Conditions.

Note: The colors along the transect profile indicate the proportions of cohorts with persistent habitat available at a given location across the transect.

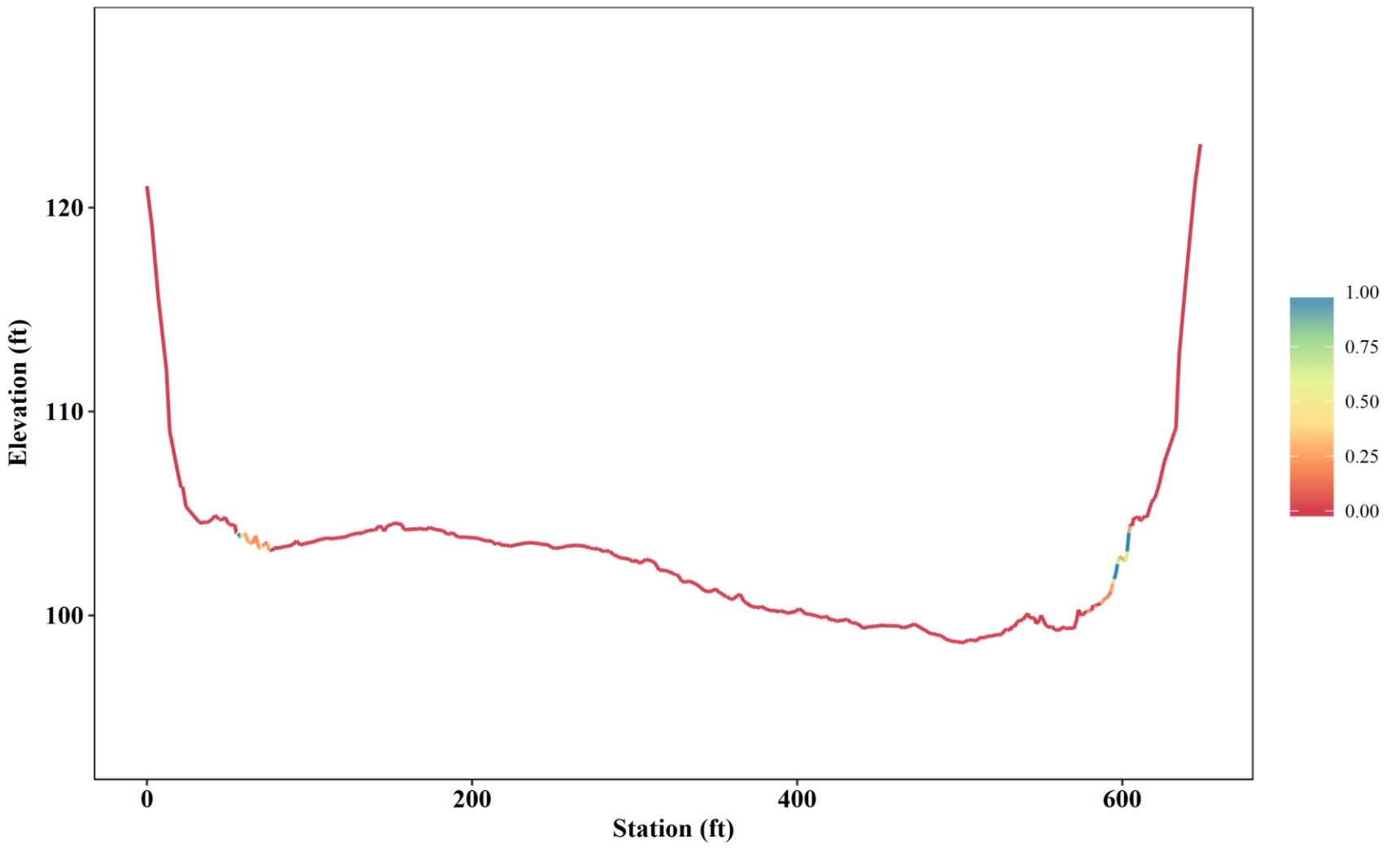


Figure A-14: Persistent Suitable Habitat Available to Proportions of 40 Juvenile Yellow Lampmussel 2-Year Cohorts (1962 through 2003) at T95 during ROR Operating Conditions.

Note: The colors along the transect profile indicate the proportions of cohorts with persistent habitat available at a given location across the transect.

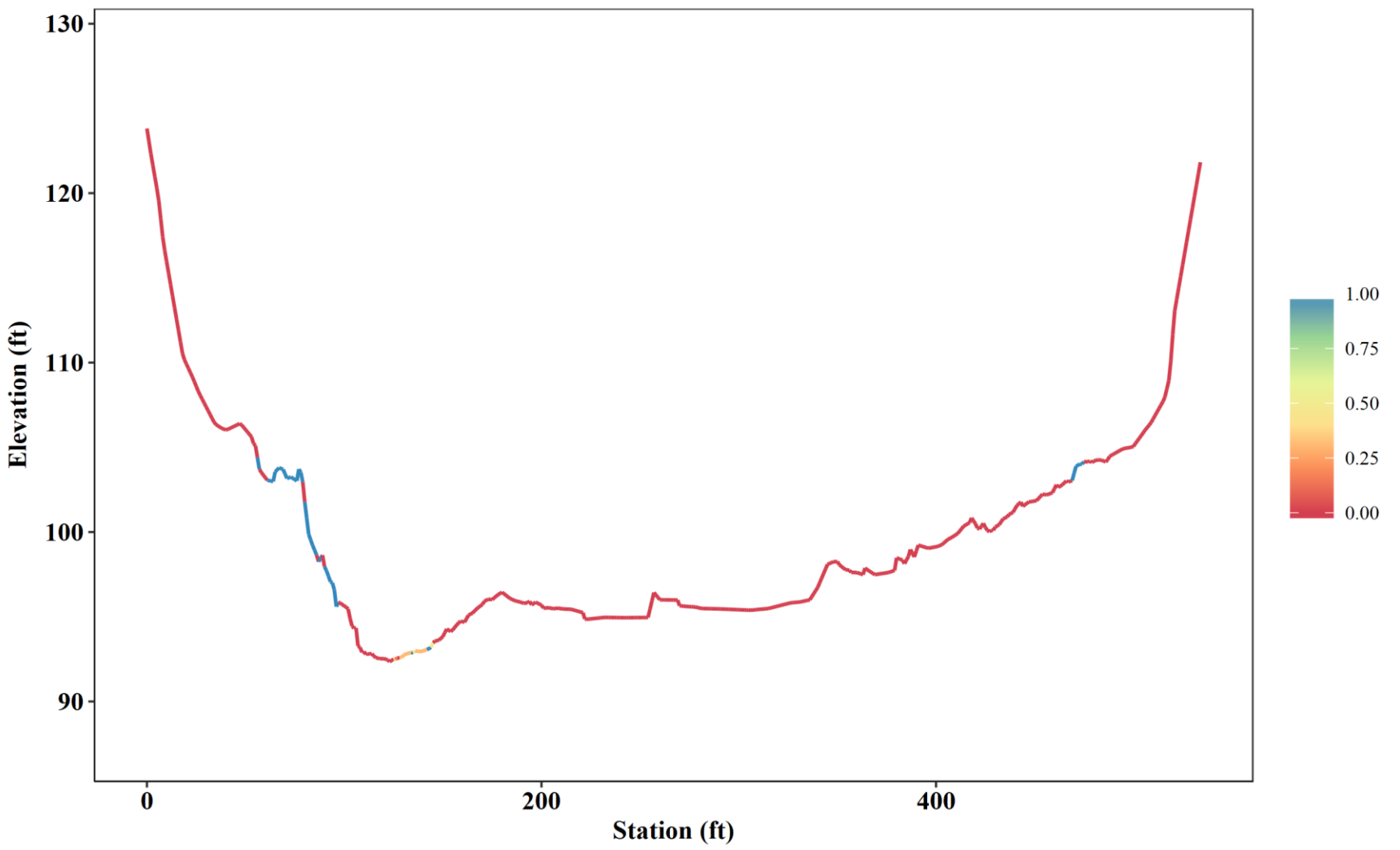


Figure A-15: Persistent Suitable Habitat Available to Proportions of 40 Juvenile Yellow Lampmussel 2-Year Cohorts (1962 through 2003) at T96 during Baseline Operating Conditions.

Note: The colors along the transect profile indicate the proportions of cohorts with persistent habitat available at a given location across the transect.

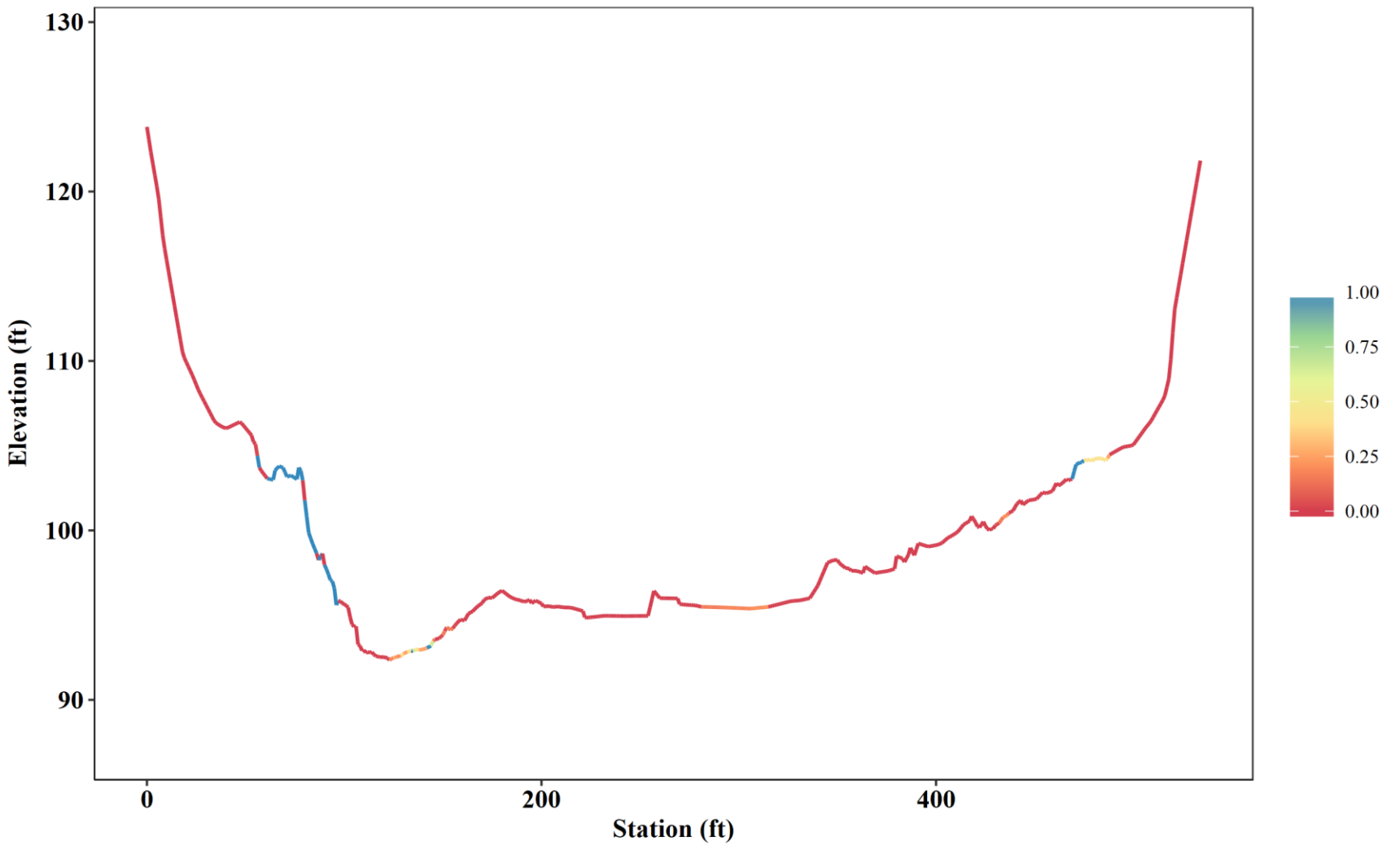


Figure A-16: Persistent Suitable Habitat Available to Proportions of 40 Juvenile Yellow Lampmussel 2-Year Cohorts (1962 through 2003) at T96 during ROR Operating Conditions.

Note: The colors along the transect profile indicate the proportions of cohorts with persistent habitat available at a given location across the transect.

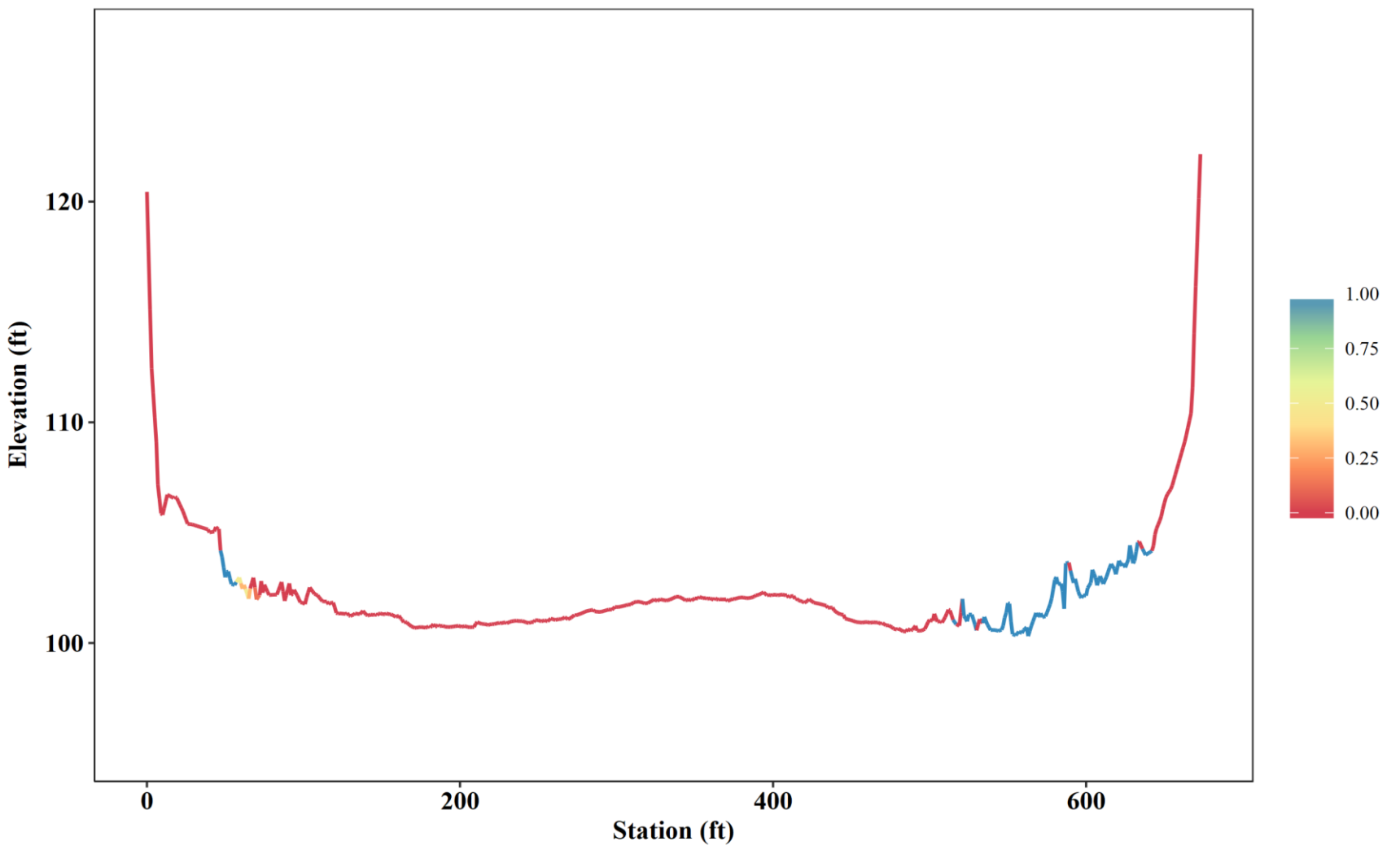


Figure A-17: Persistent Suitable Habitat Available to Proportions of 40 Juvenile Yellow Lampmussel 2-Year Cohorts (1962 through 2003) at T97 during Baseline Operating Conditions.

Note: The colors along the transect profile indicate the proportions of cohorts with persistent habitat available at a given location across the transect.

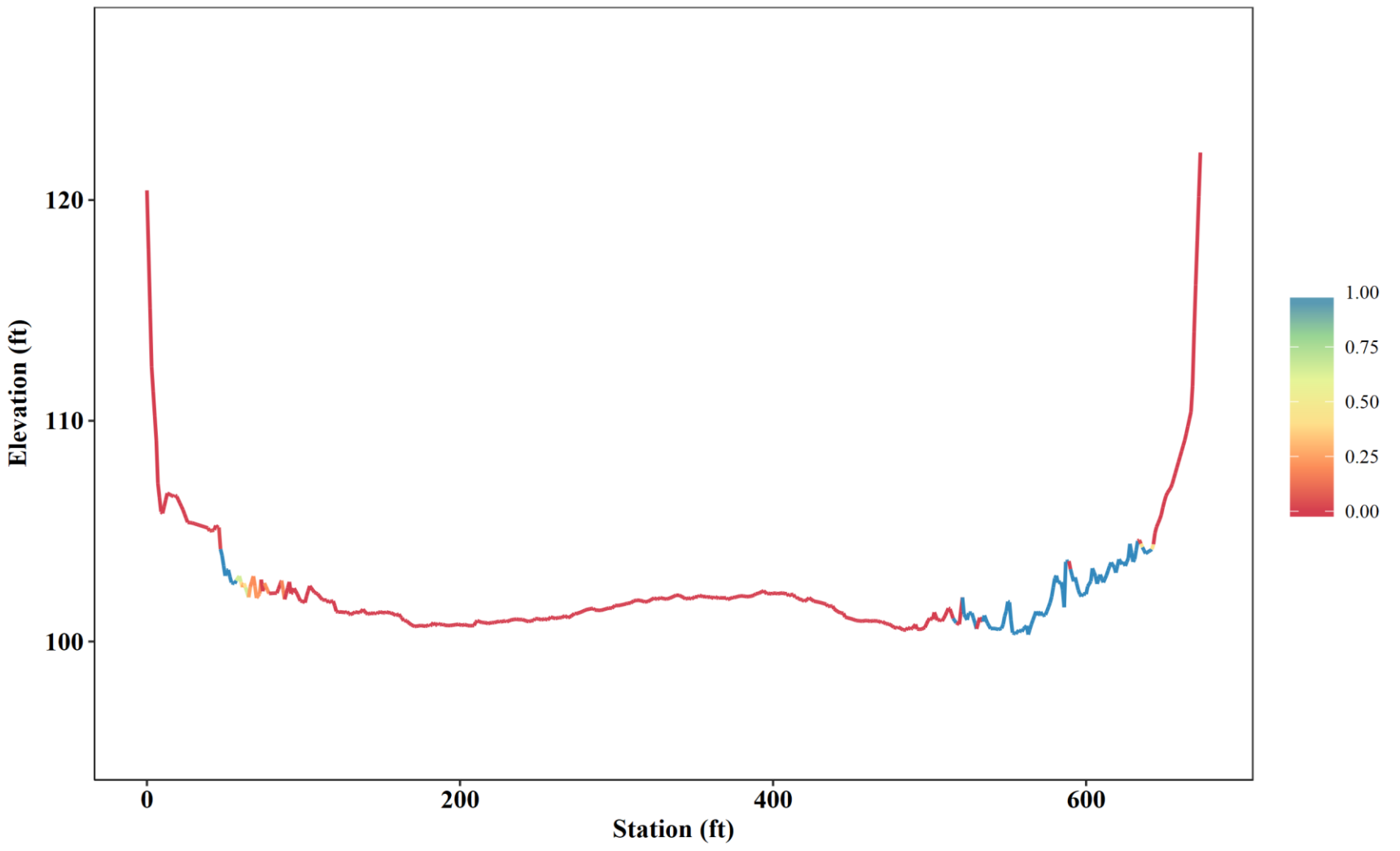


Figure A-18: Persistent Suitable Habitat Available to Proportions of 40 Juvenile Yellow Lampmussel 2-Year Cohorts (1962 through 2003) at T97 during ROR Operating Conditions.

Note: The colors along the transect profile indicate the proportions of cohorts with persistent habitat available at a given location across the transect.

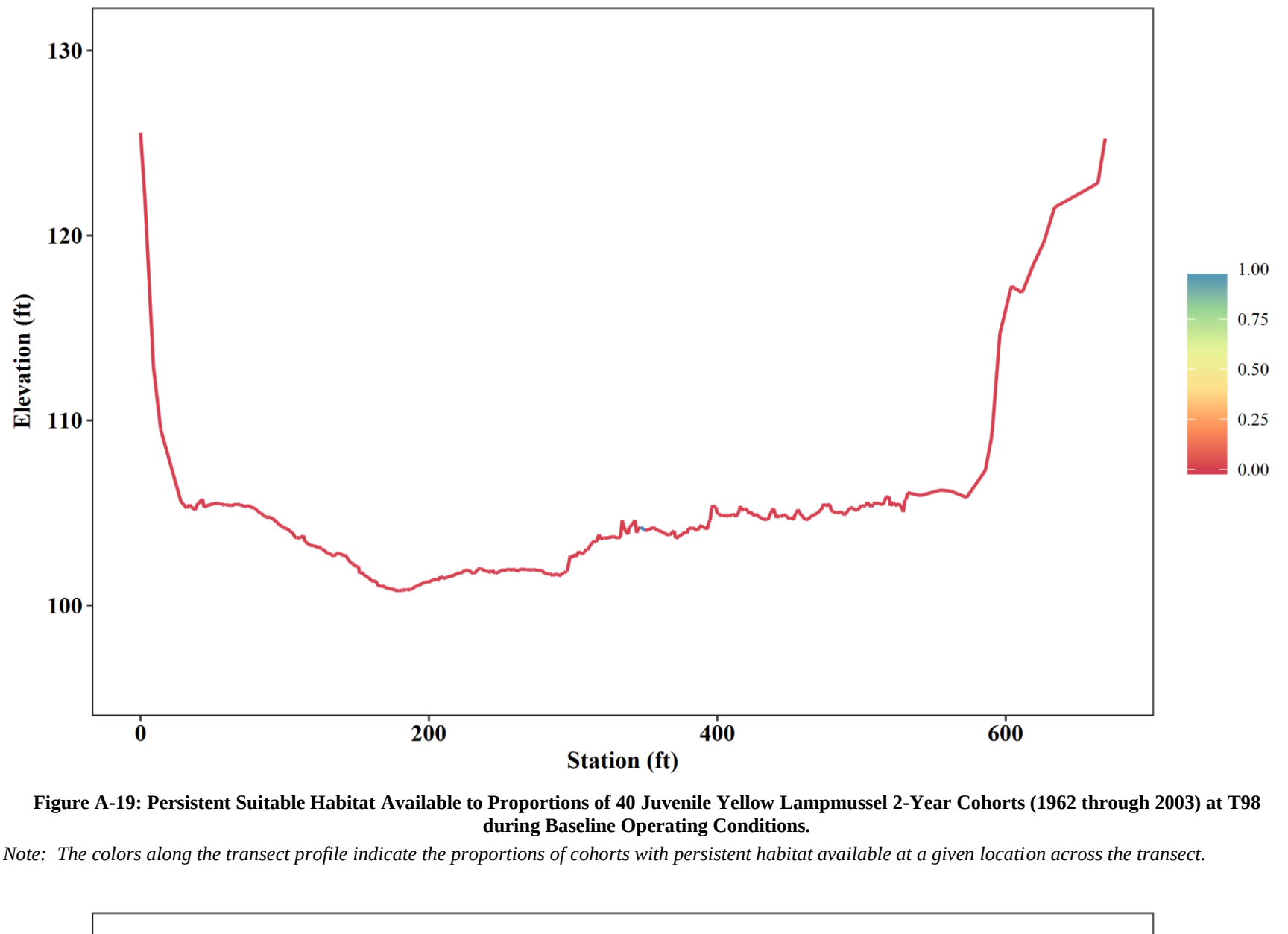


Figure A-19: Persistent Suitable Habitat Available to Proportions of 40 Juvenile Yellow Lampmussel 2-Year Cohorts (1962 through 2003) at T98 during Baseline Operating Conditions.

Note: The colors along the transect profile indicate the proportions of cohorts with persistent habitat available at a given location across the transect.

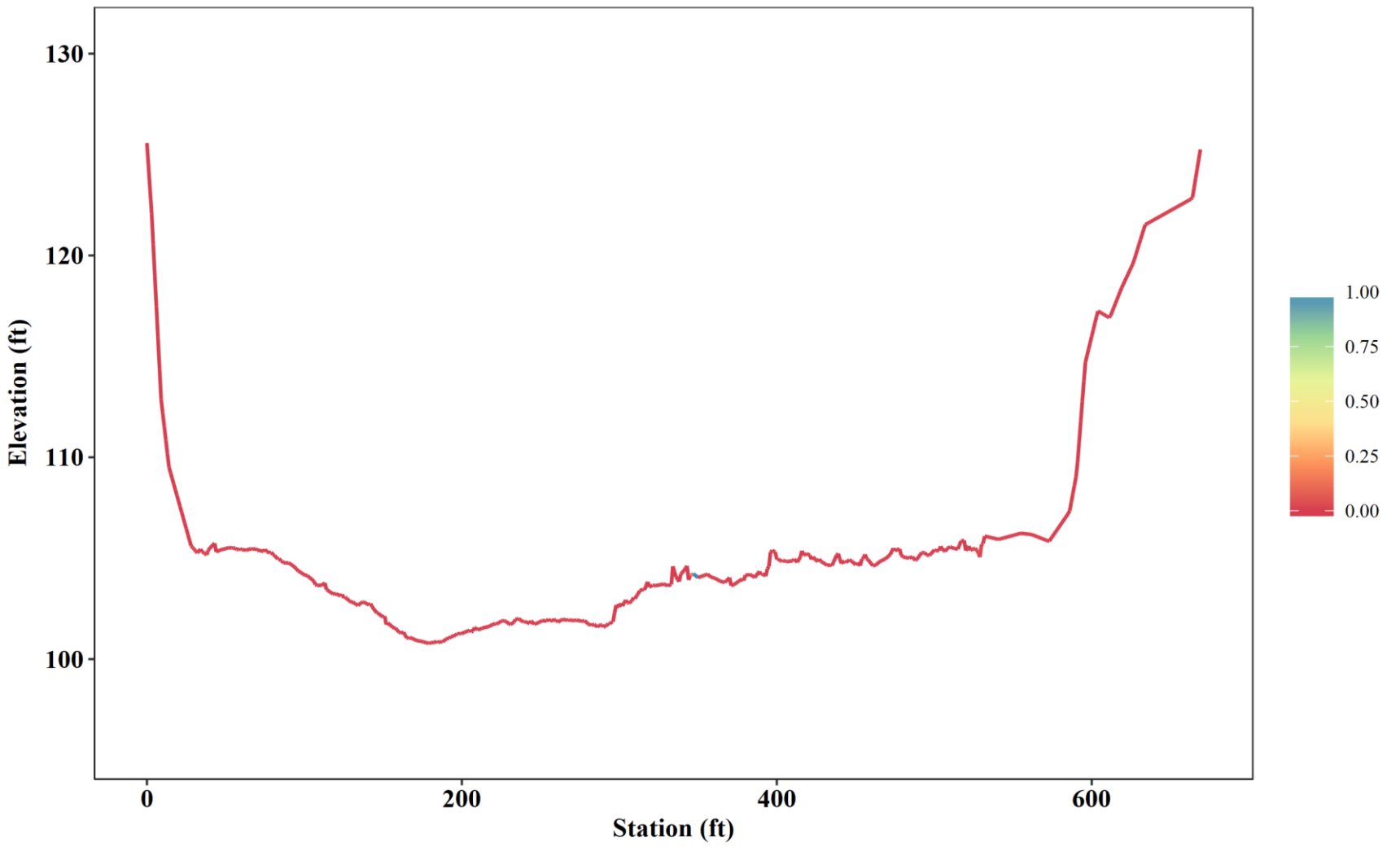


Figure A-20: Persistent Suitable Habitat Available to Proportions of 40 Juvenile Yellow Lampmussel 2-Year Cohorts (1962 through 2003) at T98 during ROR Operating Conditions.

Note: The colors along the transect profile indicate the proportions of cohorts with persistent habitat available at a given location across the transect.

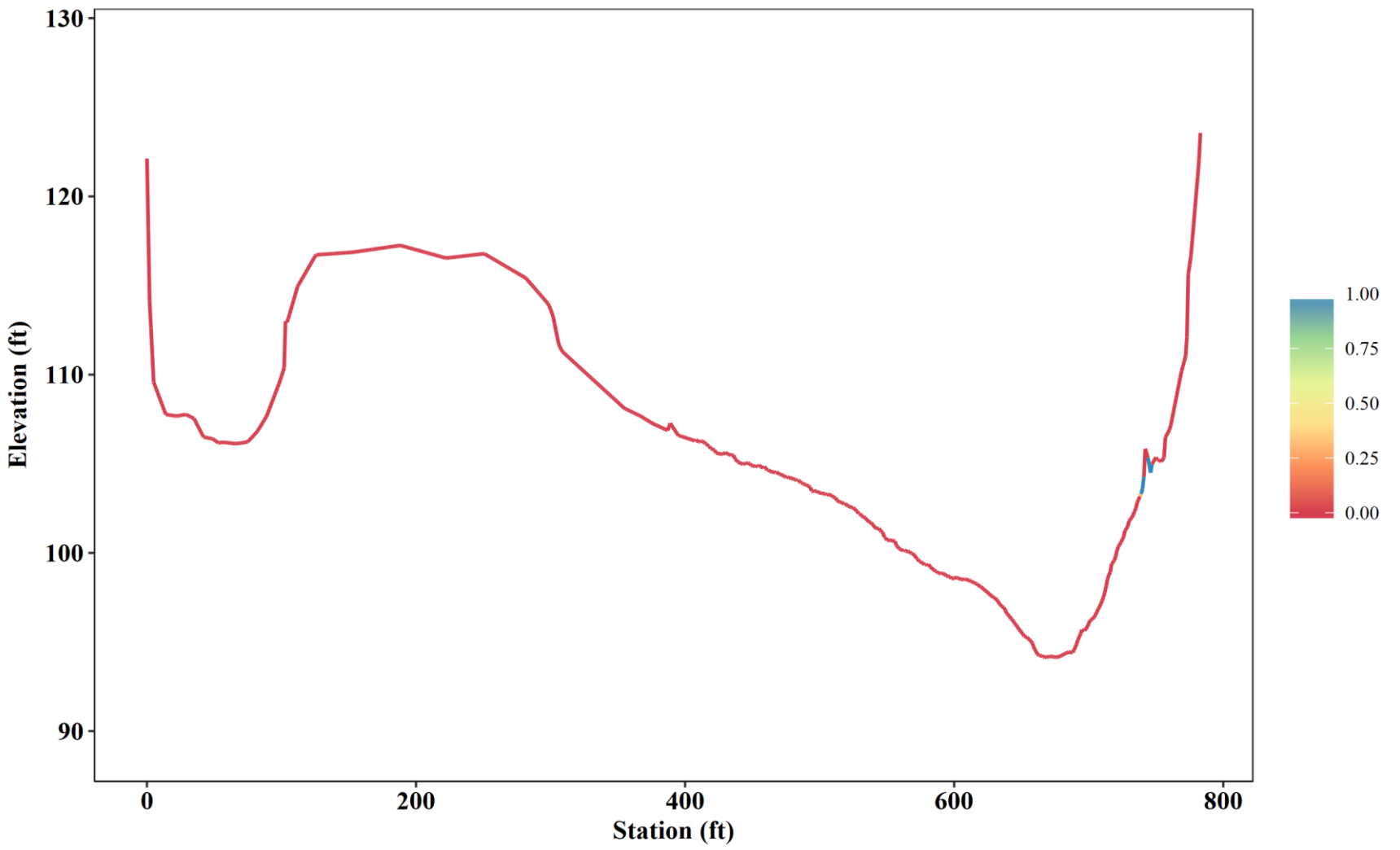


Figure A-21: Persistent Suitable Habitat Available to Proportions of 40 Juvenile Yellow Lampmussel 2-Year Cohorts (1962 through 2003) at T99 during Baseline Operating Conditions.

Note: The colors along the transect profile indicate the proportions of cohorts with persistent habitat available at a given location across the transect.

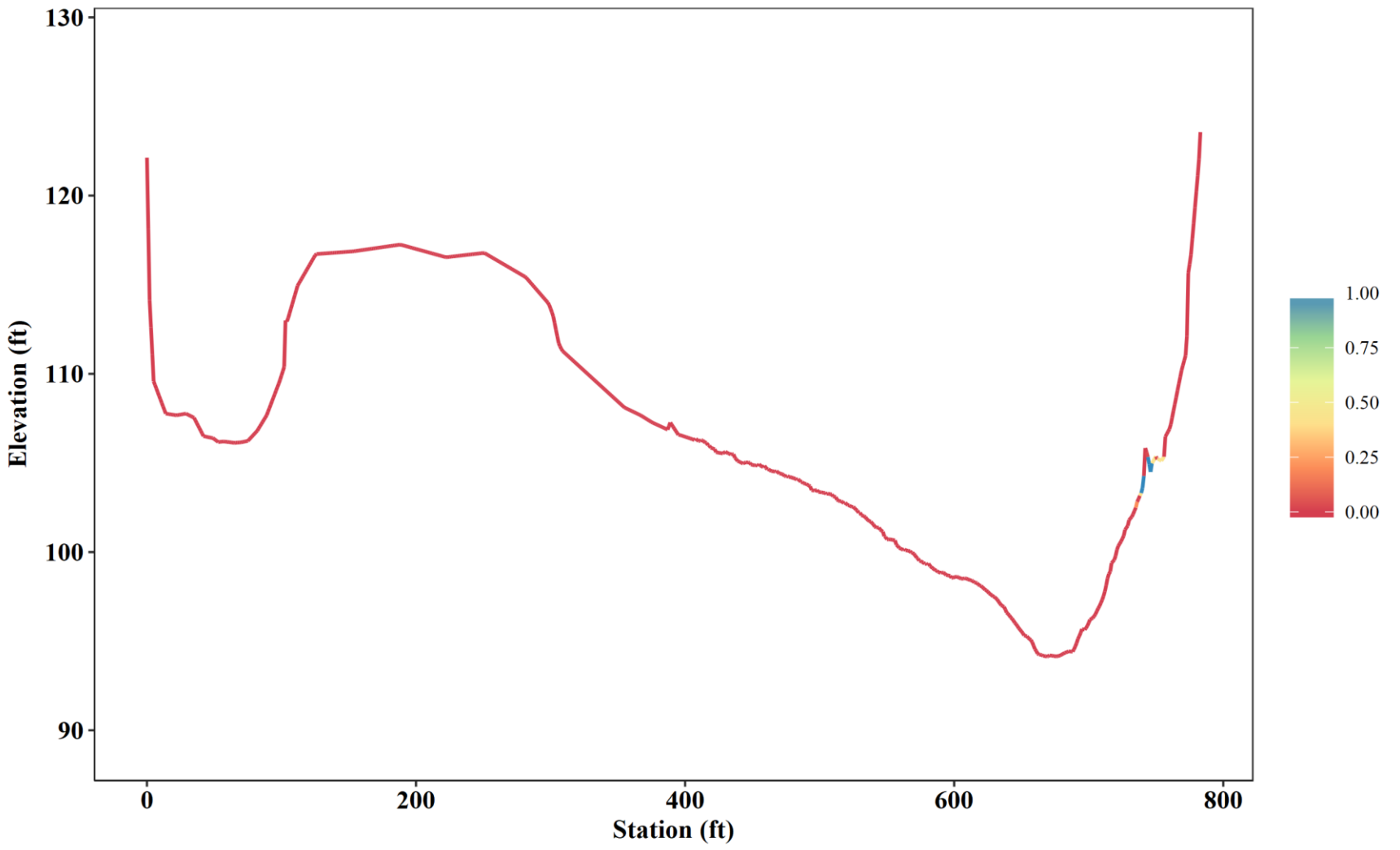


Figure A-22: Persistent Suitable Habitat Available to Proportions of 40 Juvenile Yellow Lampmussel 2-Year Cohorts (1962 through 2003) at T99 during ROR Operating Conditions.

Note: The colors along the transect profile indicate the proportions of cohorts with persistent habitat available at a given location across the transect.

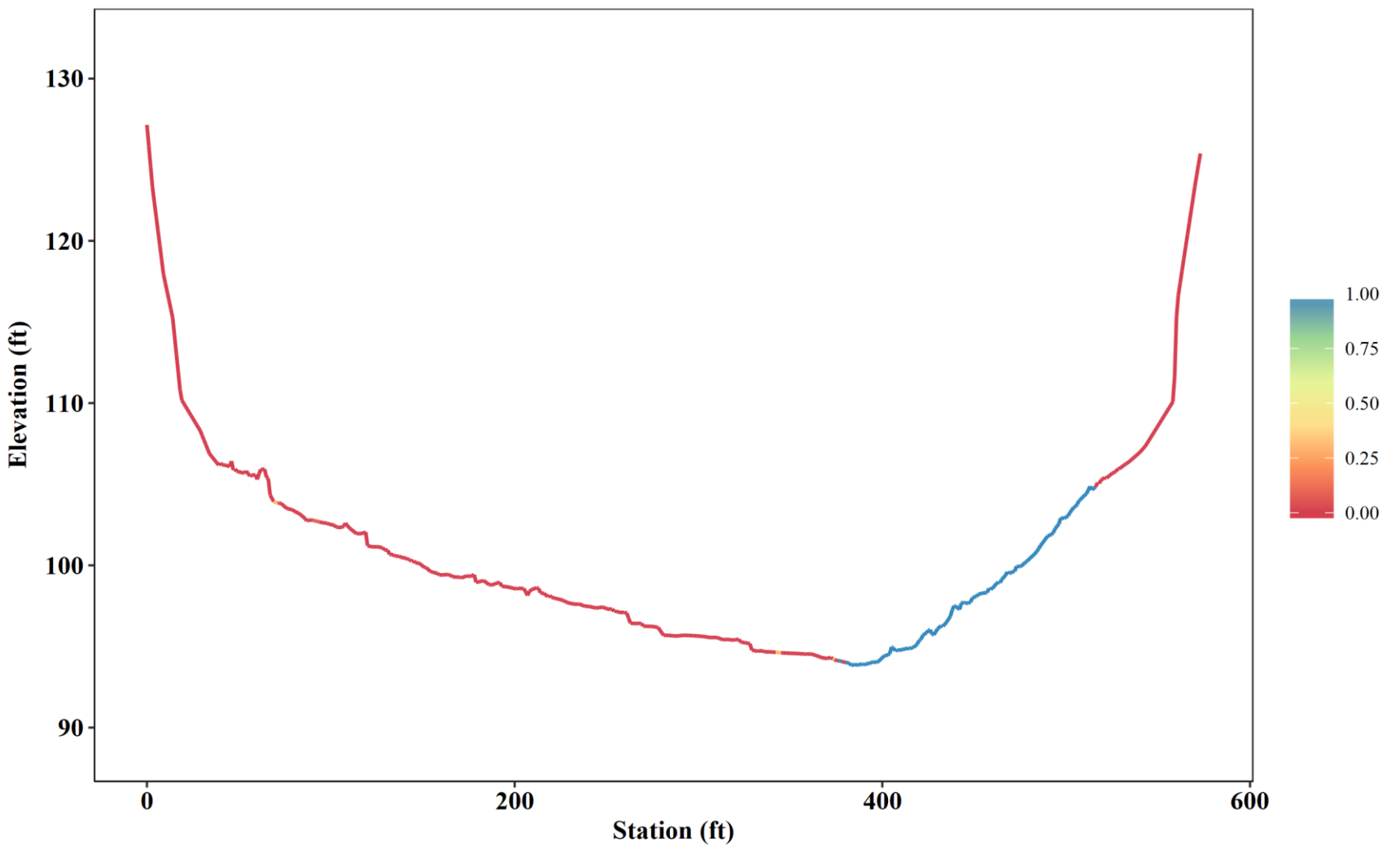


Figure A-23: Persistent Suitable Habitat Available to Proportions of 40 Juvenile Yellow Lampmussel 2-Year Cohorts (1962 through 2003) at T100 during Baseline Operating Conditions.

Note: The colors along the transect profile indicate the proportions of cohorts with persistent habitat available at a given location across the transect.

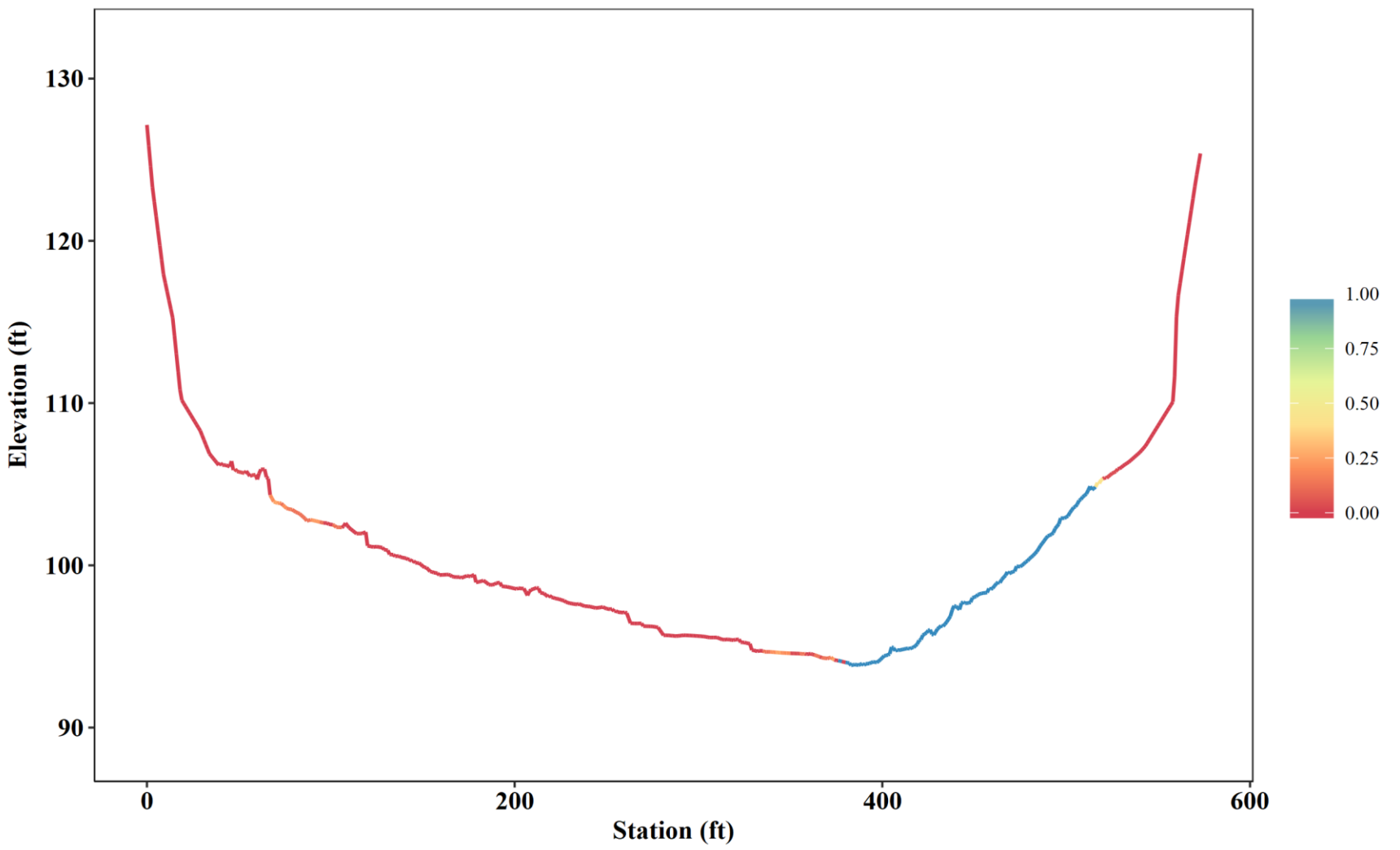


Figure A-24: Persistent Suitable Habitat Available to Proportions of 40 Juvenile Yellow Lampmussel 2-Year Cohorts (1962 through 2003) at T100 during ROR Operating Conditions.

Note: The colors along the transect profile indicate the proportions of cohorts with persistent habitat available at a given location across the transect.

APPENDIX B: ADULT YELLOW LAMPMUSSEL PERSISTENT HABITAT TRANSECT PLOTS – BASELINE AND ROR COMPARISON

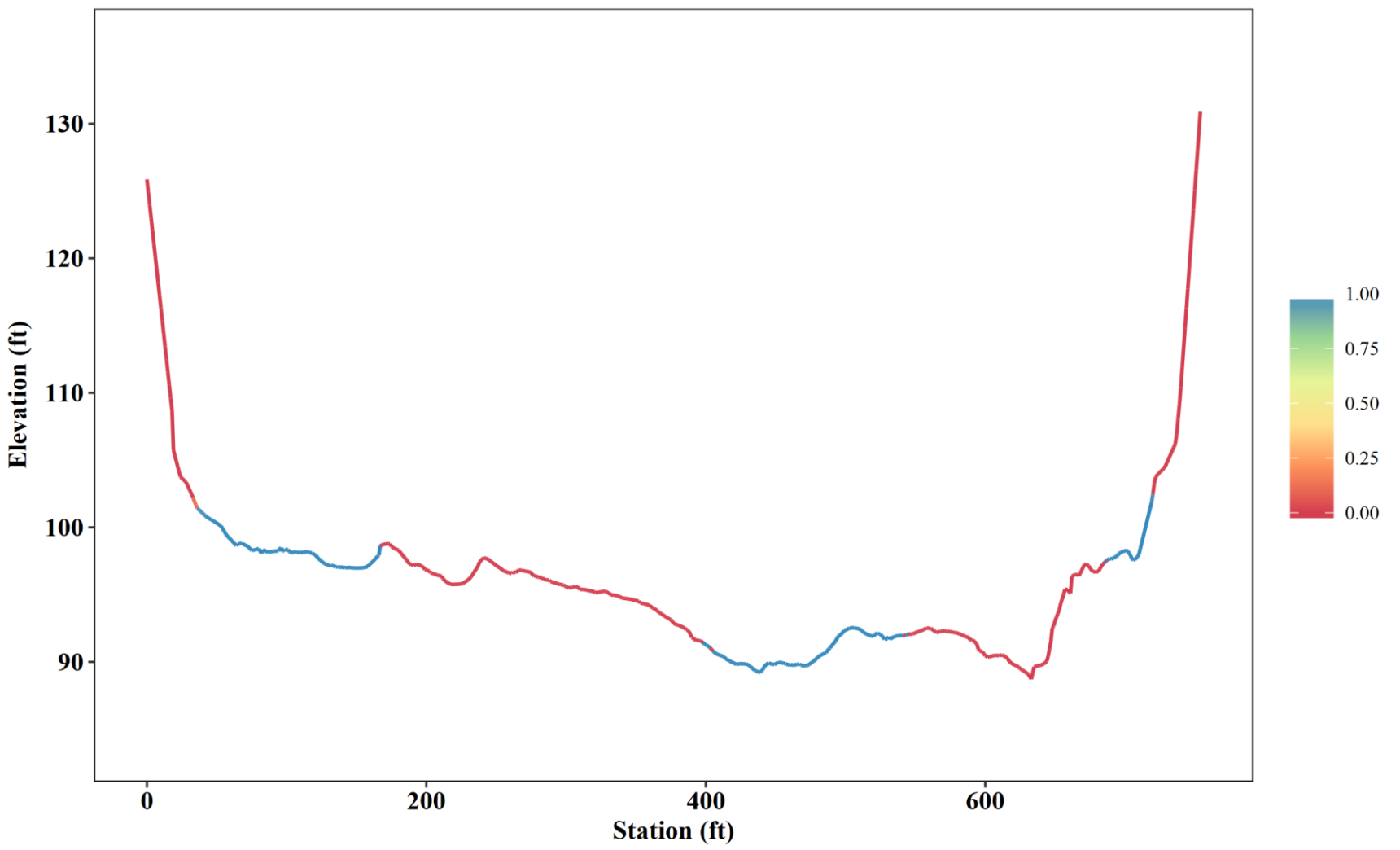


Figure B-1: Persistent Suitable Habitat Available to Proportions of Years for Adult Yellow Lampmussel (1962 through 2003) at T87 during Baseline Operating Conditions.

Note: The colors along the transect profile indicate the proportions of years with persistent habitat available at a given location across the transect.

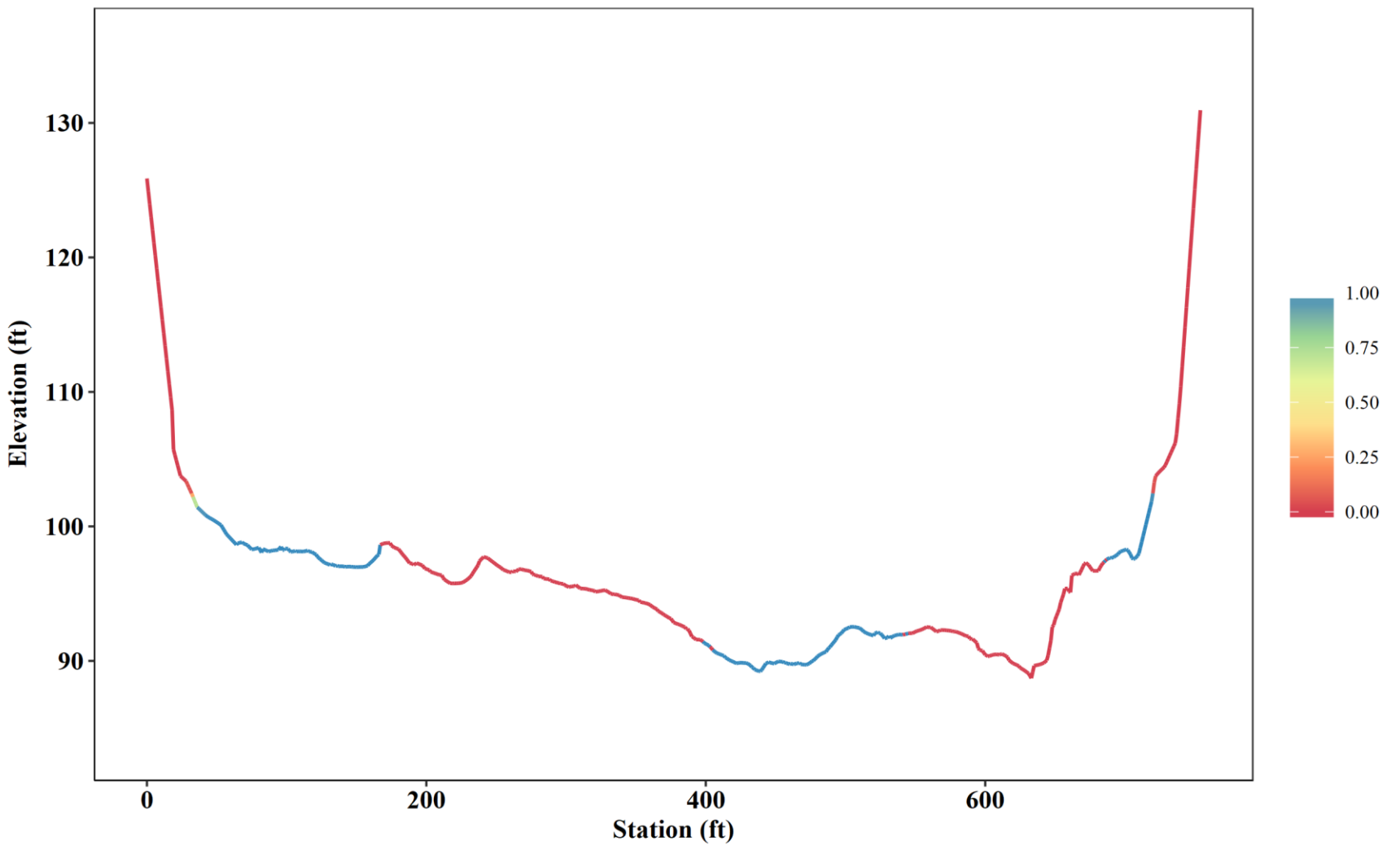


Figure B-2: Persistent Suitable Habitat Available to Proportions of Years for Adult Yellow Lampmussel (1962 through 2003) at T87 during ROR Operating Conditions.

Note: The colors along the transect profile indicate the proportions of years with persistent habitat available at a given location across the transect.

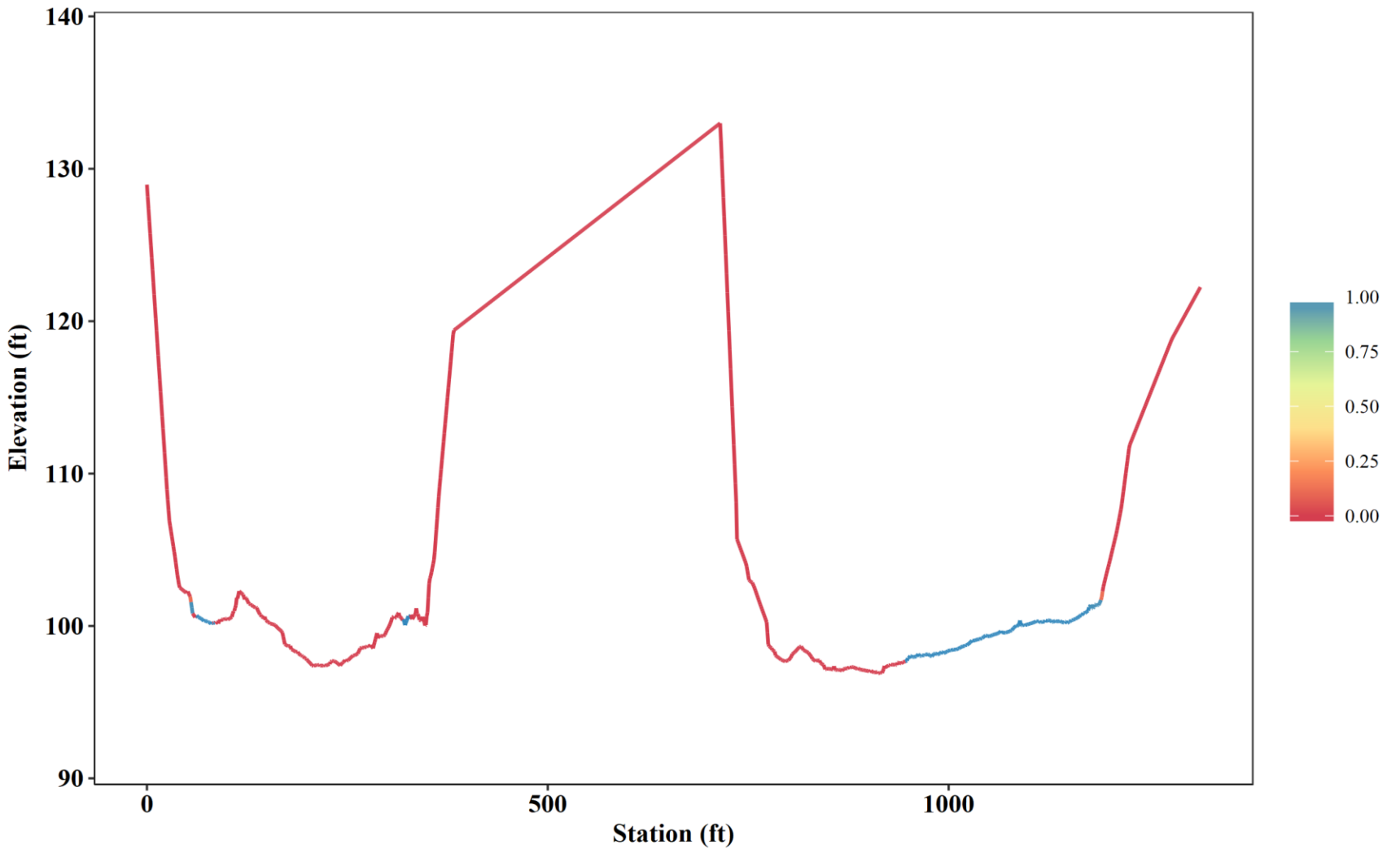


Figure B-3: Persistent Suitable Habitat Available to Proportions of Years for Adult Yellow Lampmussel (1962 through 2003) at T88 during Baseline Operating Conditions.

Note: The colors along the transect profile indicate the proportions of years with persistent habitat available at a given location across the transect.

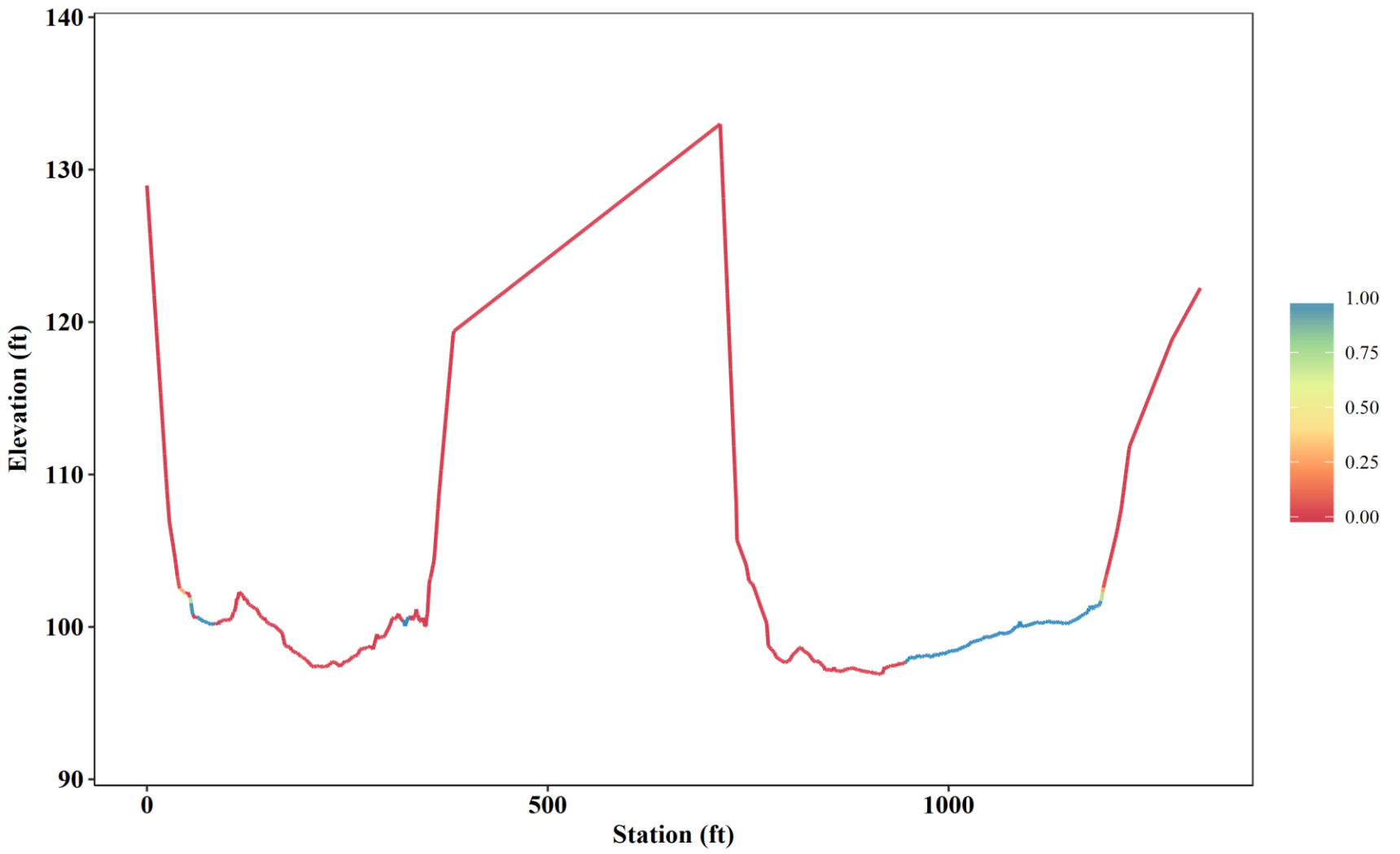


Figure B-4: Persistent Suitable Habitat Available to Proportions of Years for Adult Yellow Lampmussel (1962 through 2003) at T88 during ROR Operating Conditions.

Note: The colors along the transect profile indicate the proportions of years with persistent habitat available at a given location across the transect.

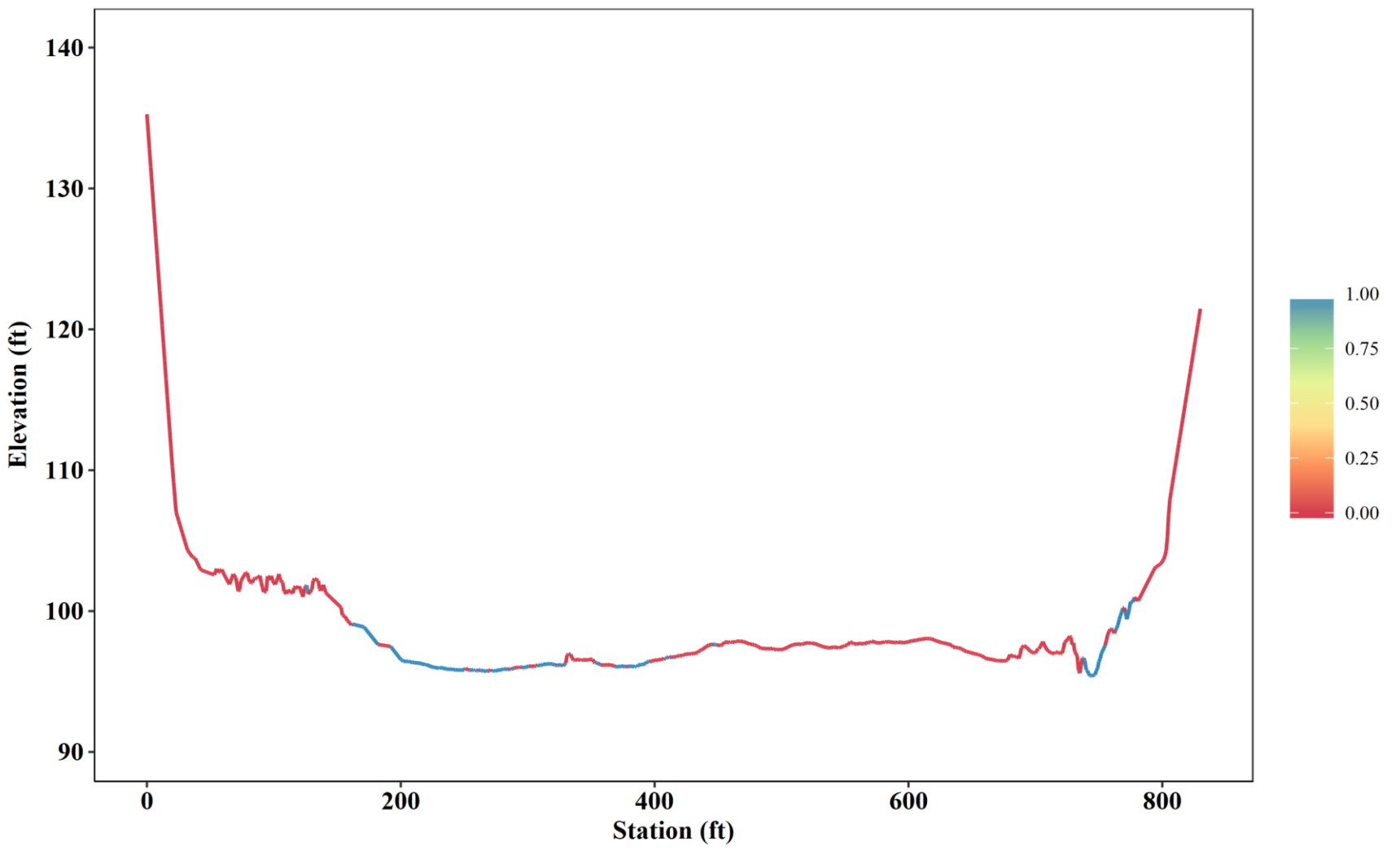


Figure B-5: Persistent Suitable Habitat Available to Proportions of Years for Adult Yellow Lampmussel (1962 through 2003) at T89 during Baseline Operating Conditions.

Note: The colors along the transect profile indicate the proportions of years with persistent habitat available at a given location across the transect.

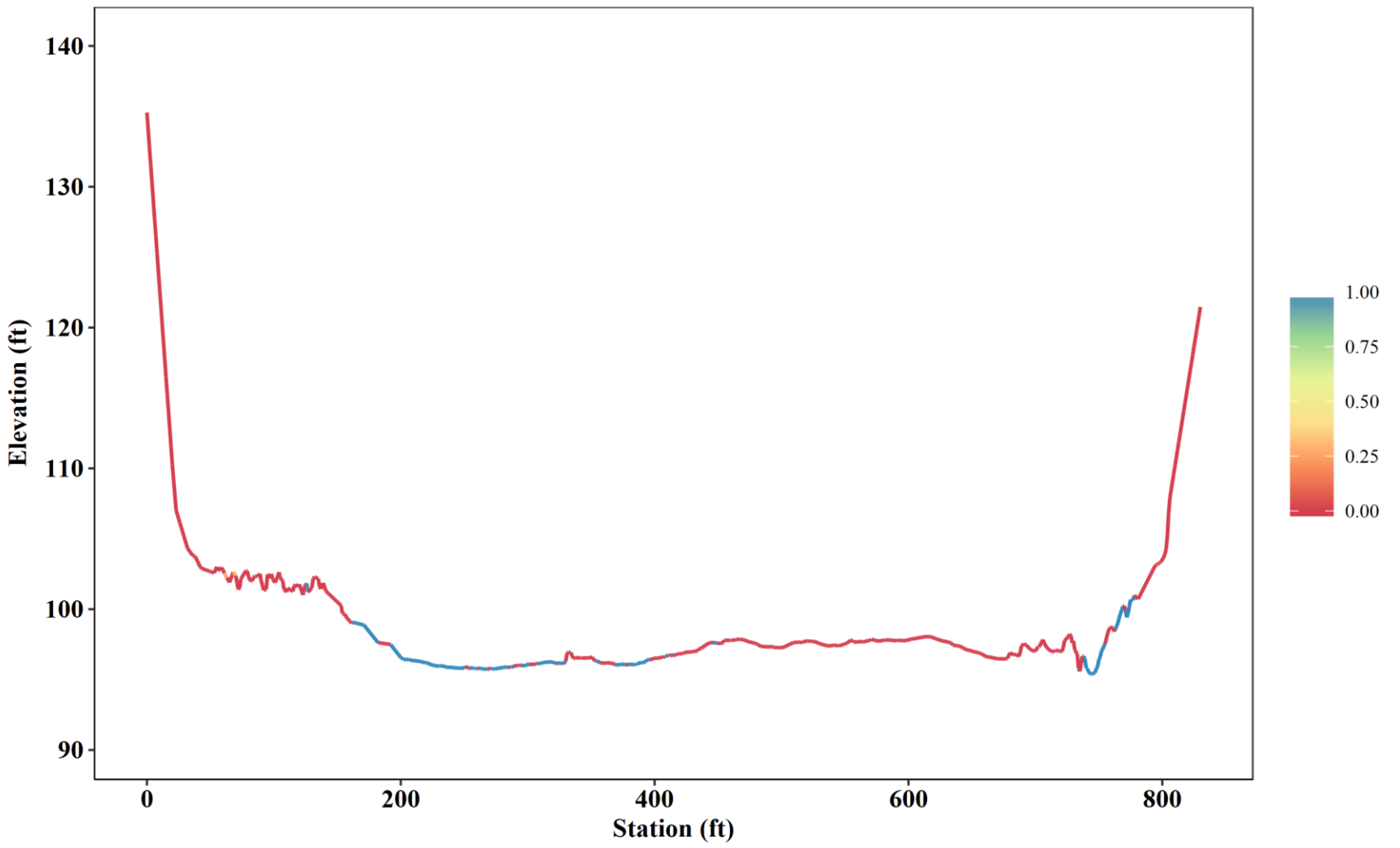


Figure B-6: Persistent Suitable Habitat Available to Proportions of Years for Adult Yellow Lampmussel (1962 through 2003) at T89 during ROR Operating Conditions.

Note: The colors along the transect profile indicate the proportions of years with persistent habitat available at a given location across the transect

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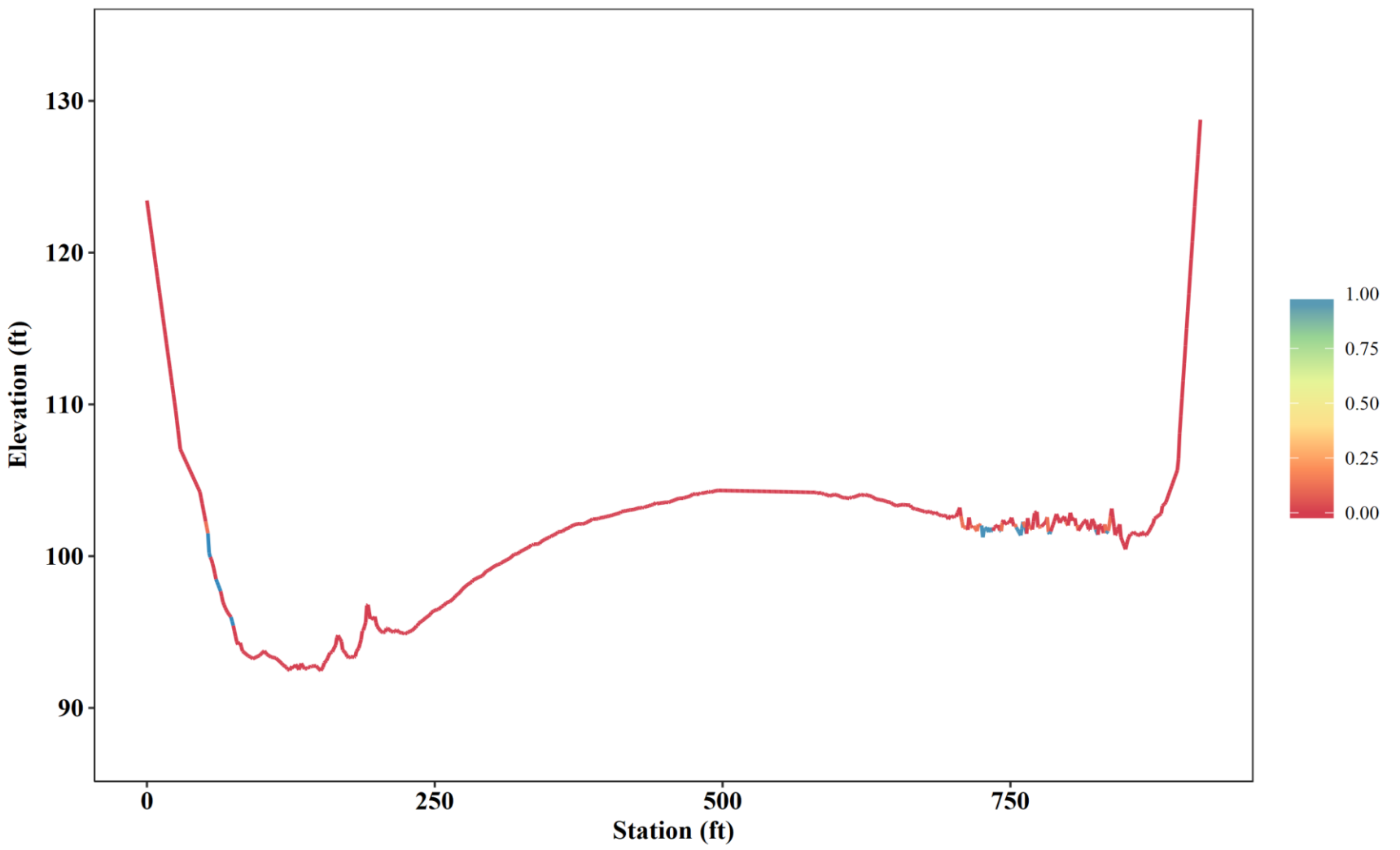

Figure B-7: Persistent Suitable Habitat Available to Proportions of Years for Adult Yellow Lampmussel (1962 through 2003) at T90 during Baseline Operating Conditions.

Note: The colors along the transect profile indicate the proportions of years with persistent habitat available at a given location across the transect.

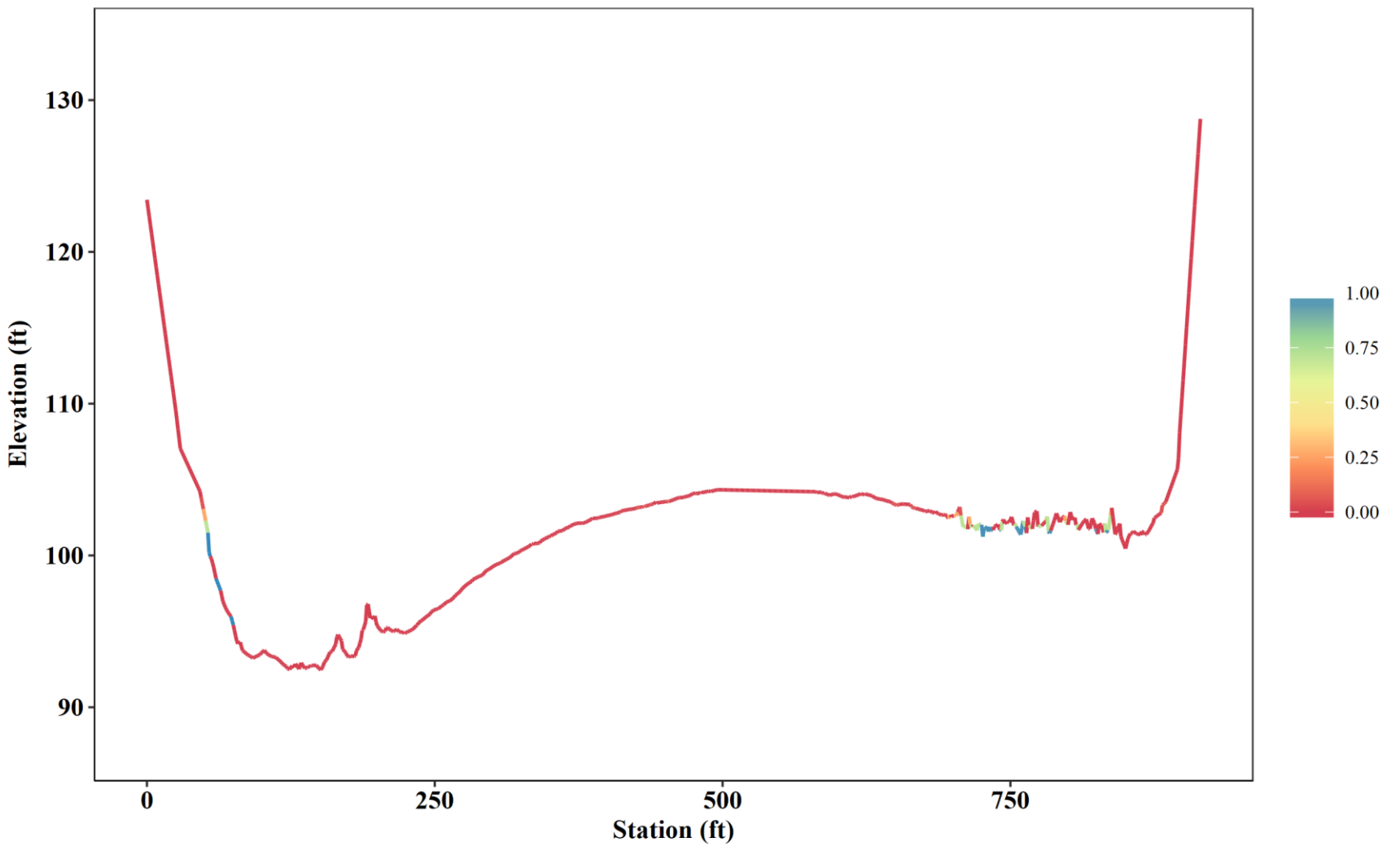

Figure B-8: Persistent Suitable Habitat Available to Proportions of Years for Adult Yellow Lampmussel (1962 through 2003) at T90 during ROR Operating Conditions.

Note: The colors along the transect profile indicate the proportions of years with persistent habitat available at a given location across the transect.

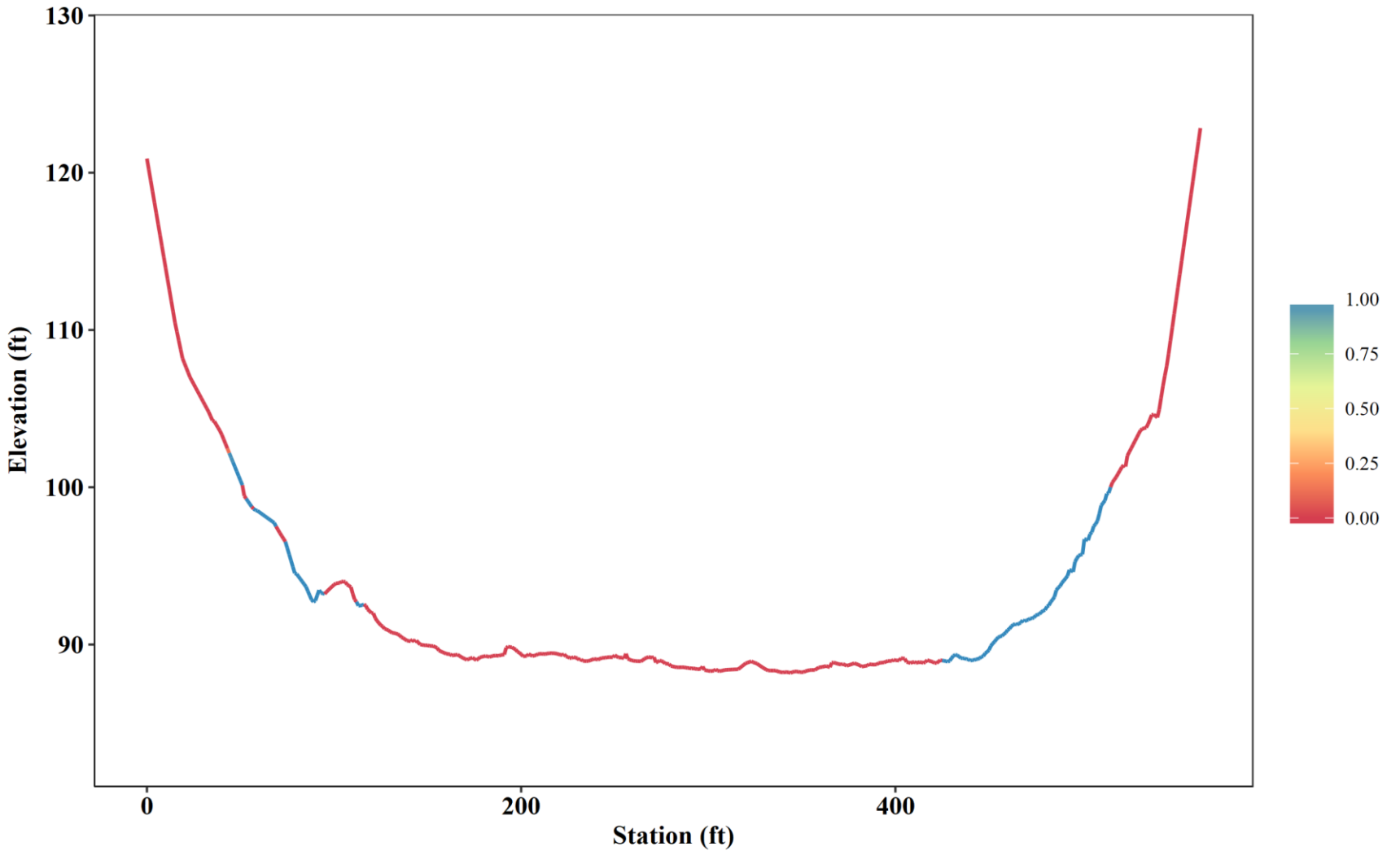

Figure B-9: Persistent Suitable Habitat Available to Proportions of Years for Adult Yellow Lampmussel (1962 through 2003) at T91 during Baseline Operating Conditions.

Note: The colors along the transect profile indicate the proportions of years with persistent habitat available at a given location across the transect.

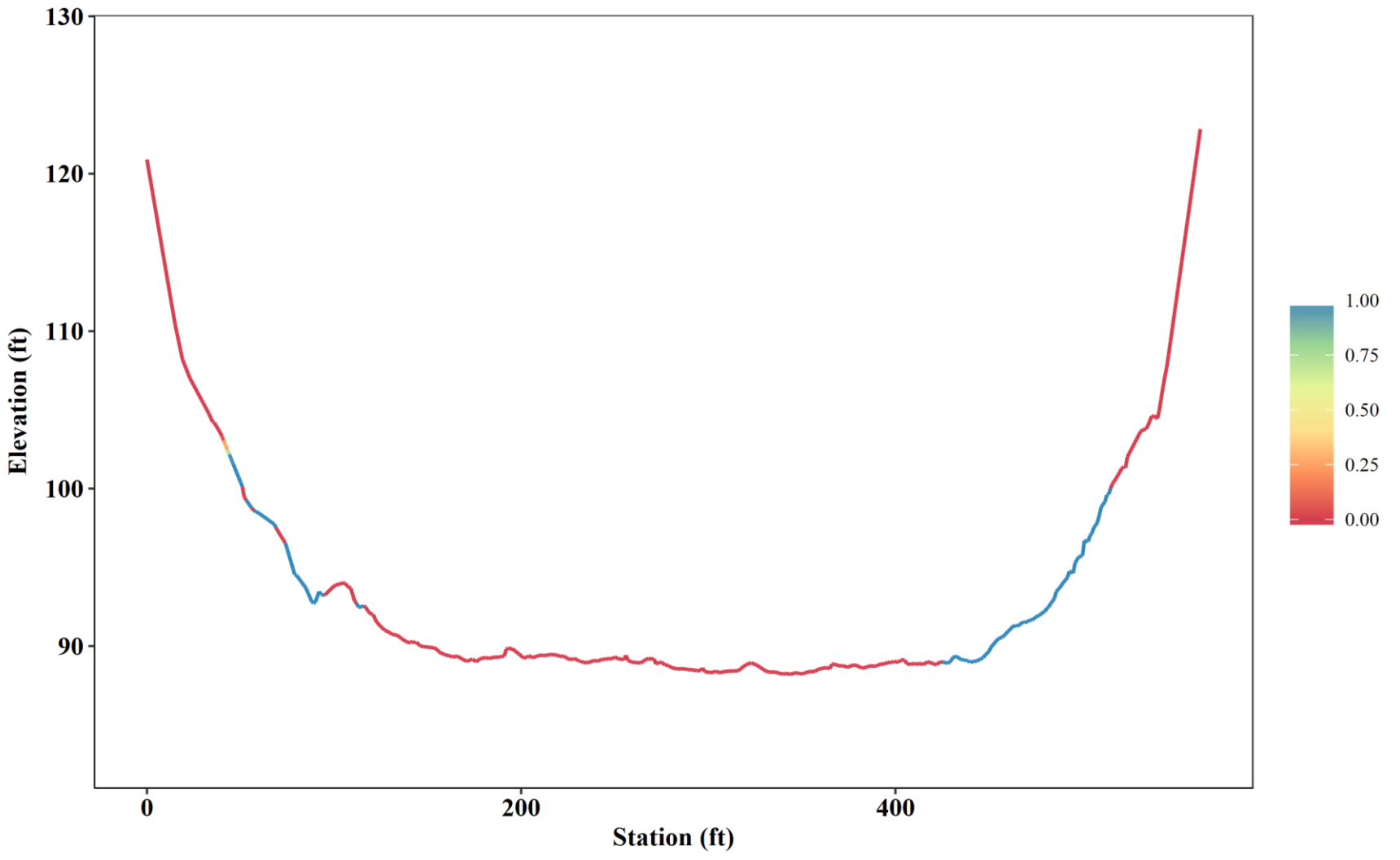

Figure B-10: Persistent Suitable Habitat Available to Proportions of Years for Adult Yellow Lampmussel (1962 through 2003) at T91 during ROR Operating Conditions.

Note: The colors along the transect profile indicate the proportions of years with persistent habitat available at a given location across the transect.

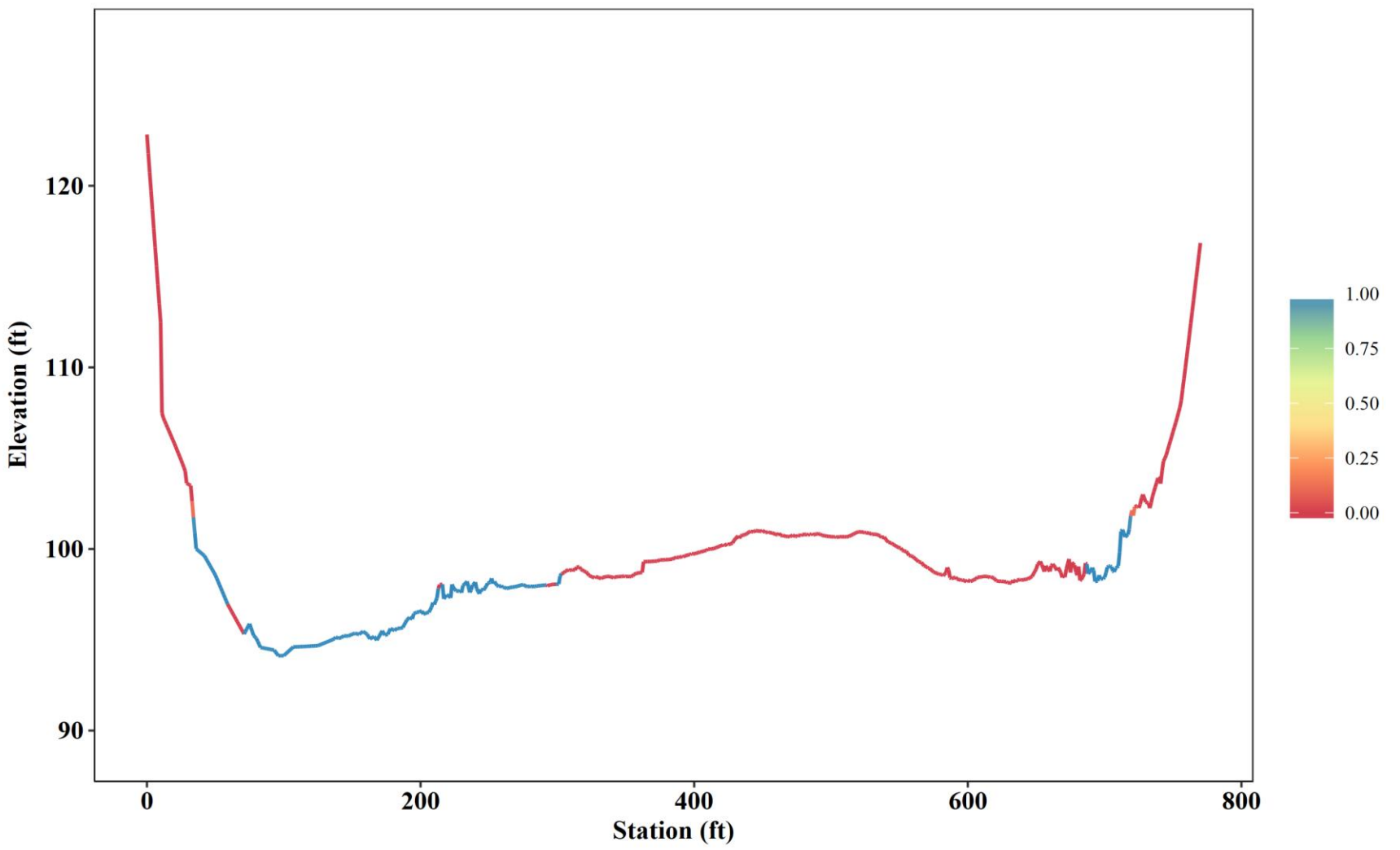

Figure B-11: Persistent Suitable Habitat Available to Proportions of Years for Adult Yellow Lampmussel (1962 through 2003) at T92 during Baseline Operating Conditions.

Note: The colors along the transect profile indicate the proportions of years with persistent habitat available at a given location across the transect.

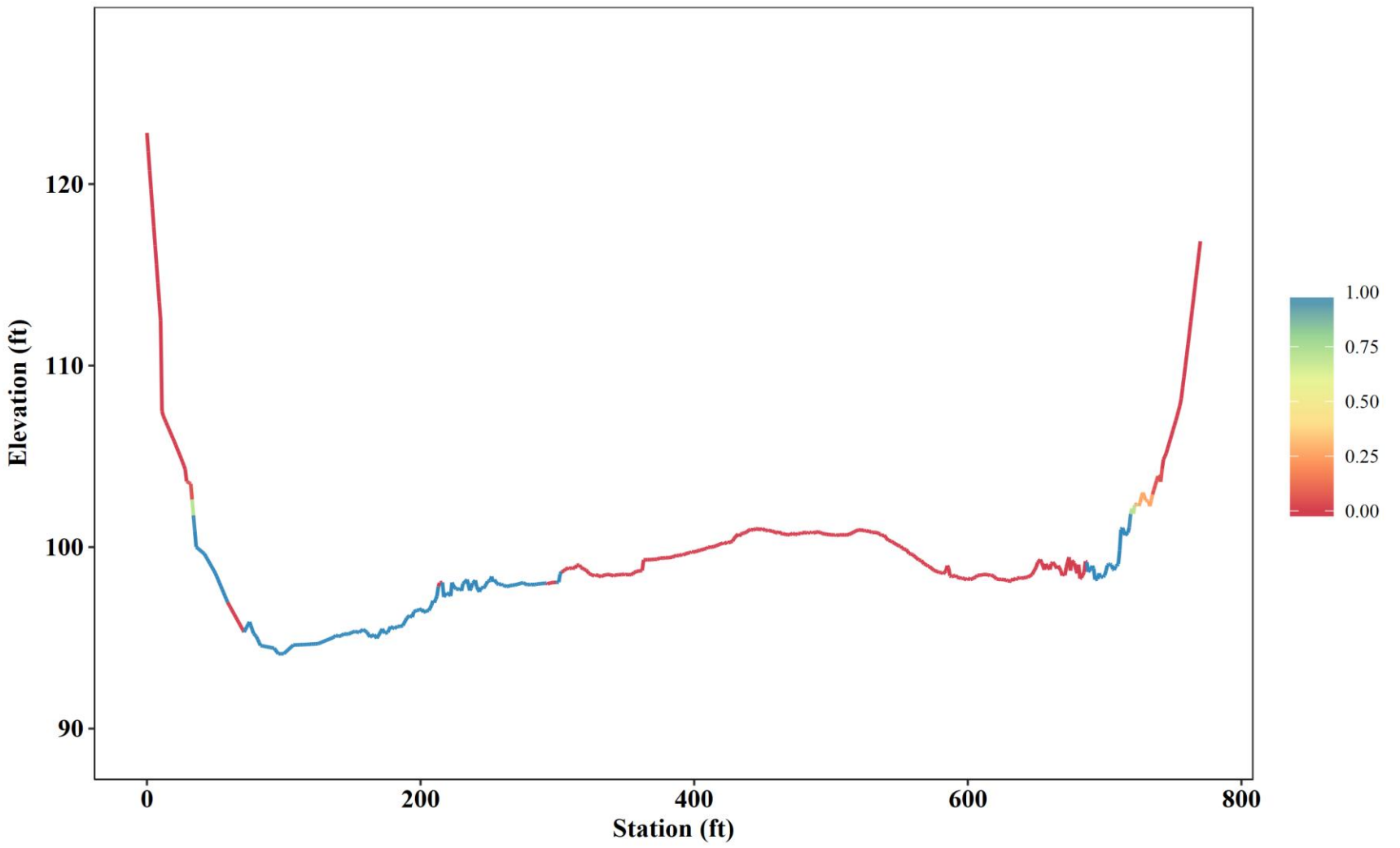

Figure B-12: Persistent Suitable Habitat Available to Proportions of Years for Adult Yellow Lampmussel (1962 through 2003) at T92 during ROR Operating Conditions.

Note: The colors along the transect profile indicate the proportions of years with persistent habitat available at a given location across the transect.

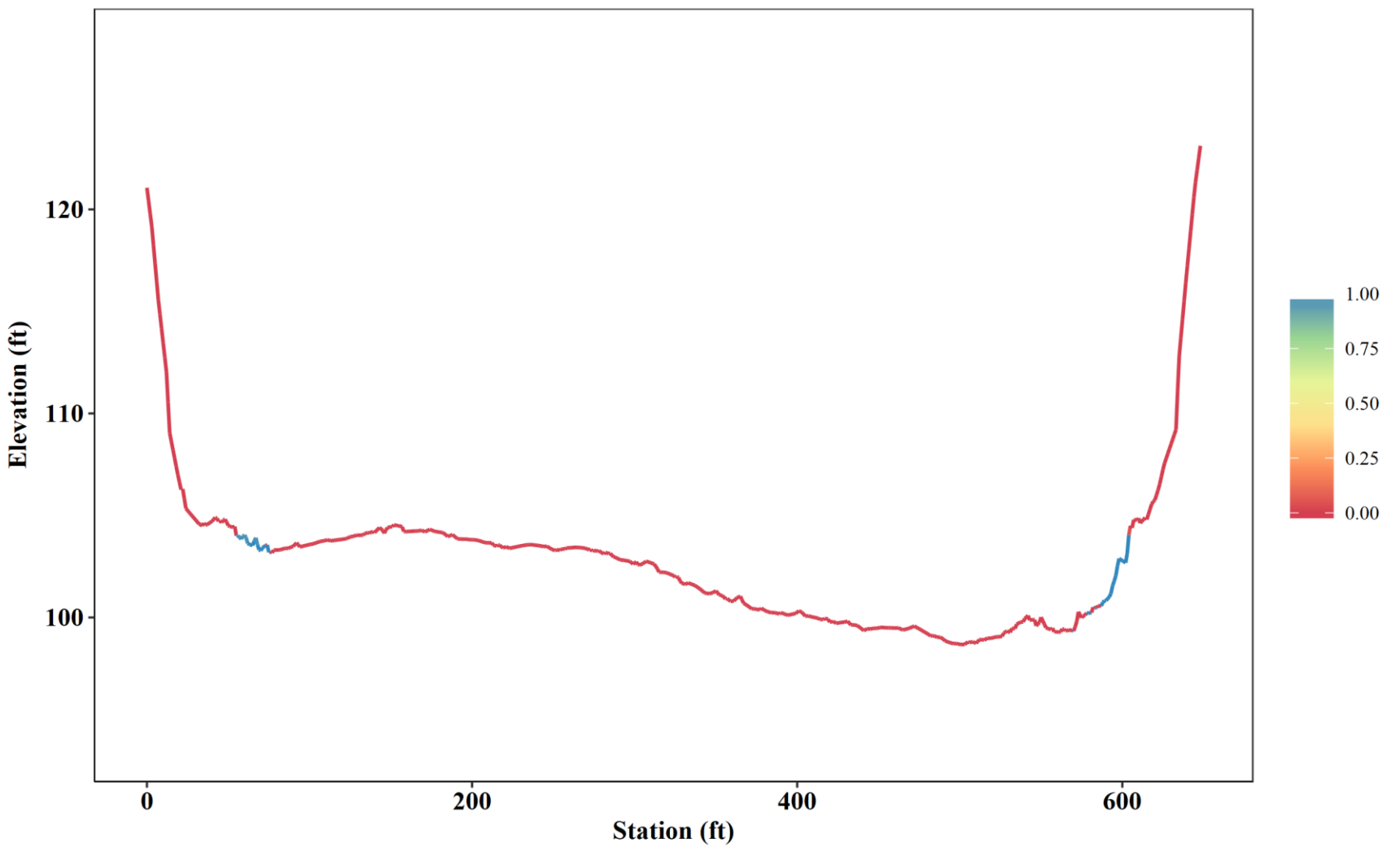

Figure B-13: Persistent Suitable Habitat Available to Proportions of Years for Adult Yellow Lampmussel (1962 through 2003) at T95 during Baseline Operating Conditions.

Note: The colors along the transect profile indicate the proportions of years with persistent habitat available at a given location across the transect.

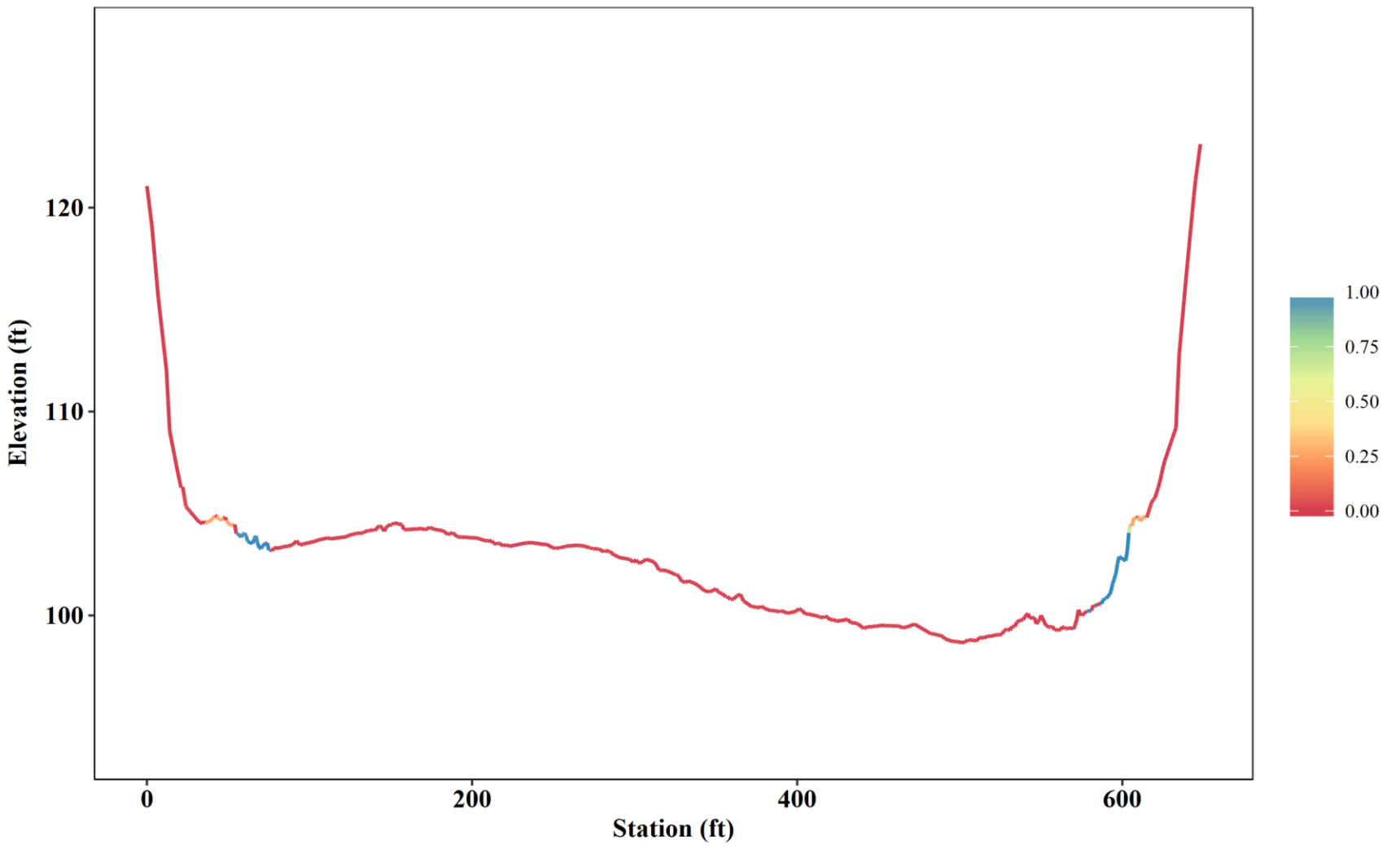

Figure B-14: Persistent Suitable Habitat Available to Proportions of Years for Adult Yellow Lampmussel (1962 through 2003) at T95 during ROR Operating Conditions.

Note: The colors along the transect profile indicate the proportions of years with persistent habitat available at a given location across the transect.

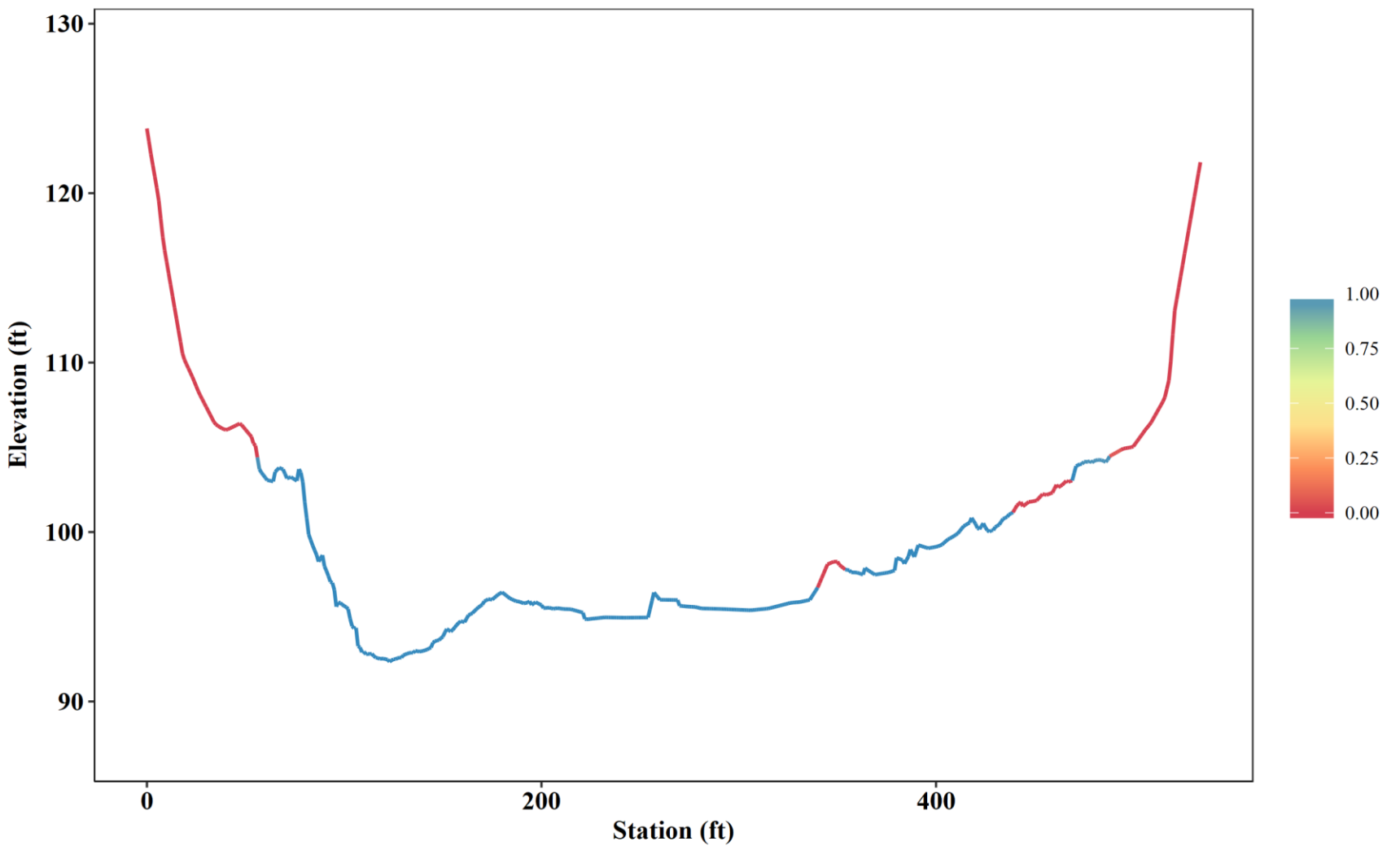

Figure B-15: Persistent Suitable Habitat Available to Proportions of Years for Adult Yellow Lampmussel (1962 through 2003) at T96 during Baseline Operating Conditions.

Note: The colors along the transect profile indicate the proportions of years with persistent habitat available at a given location across the transect.

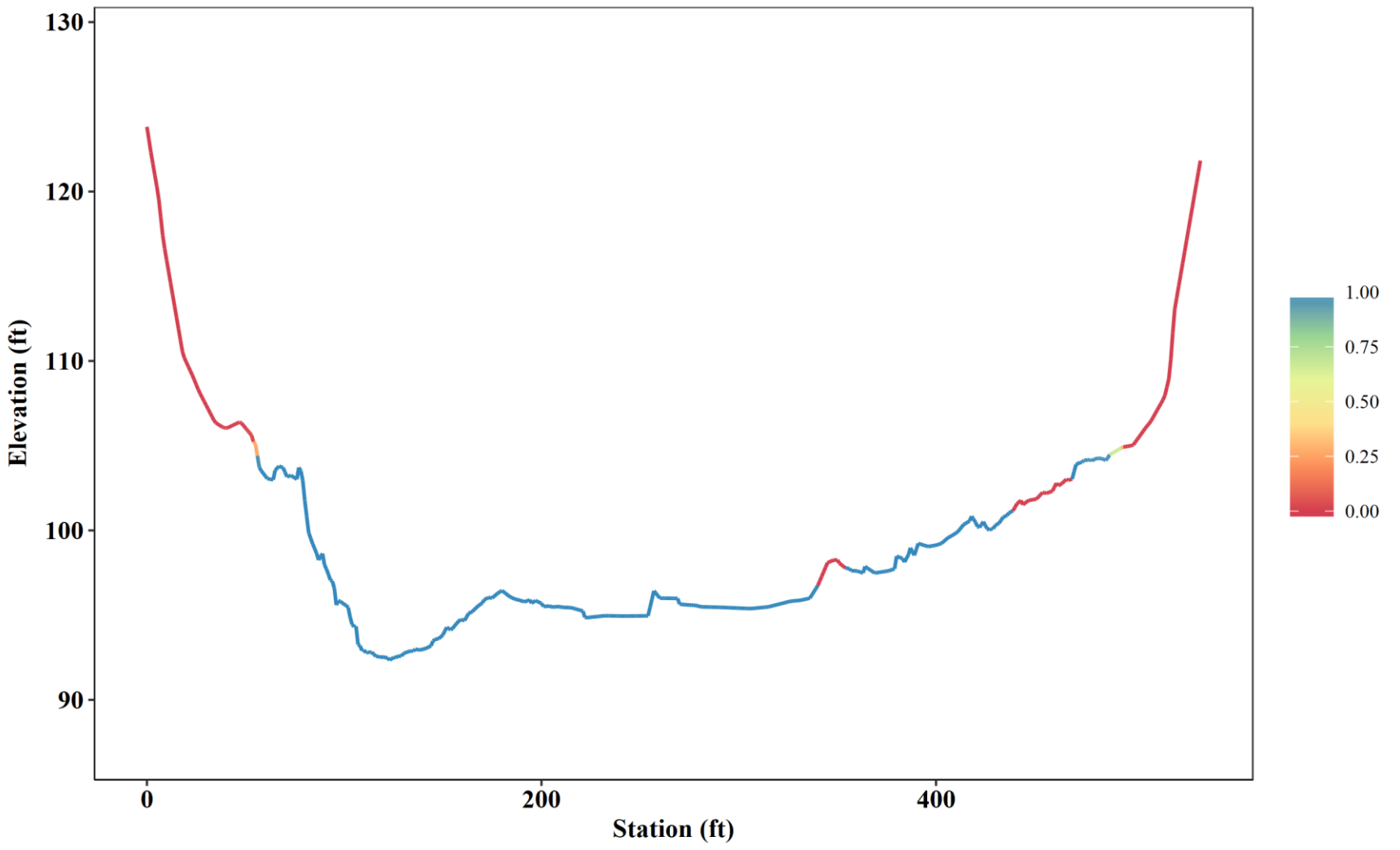

Figure B-16: Persistent Suitable Habitat Available to Proportions of Years for Adult Yellow Lampmussel (1962 through 2003) at T96 during ROR Operating Conditions.

Note: The colors along the transect profile indicate the proportions of years with persistent habitat available at a given location across the transect.

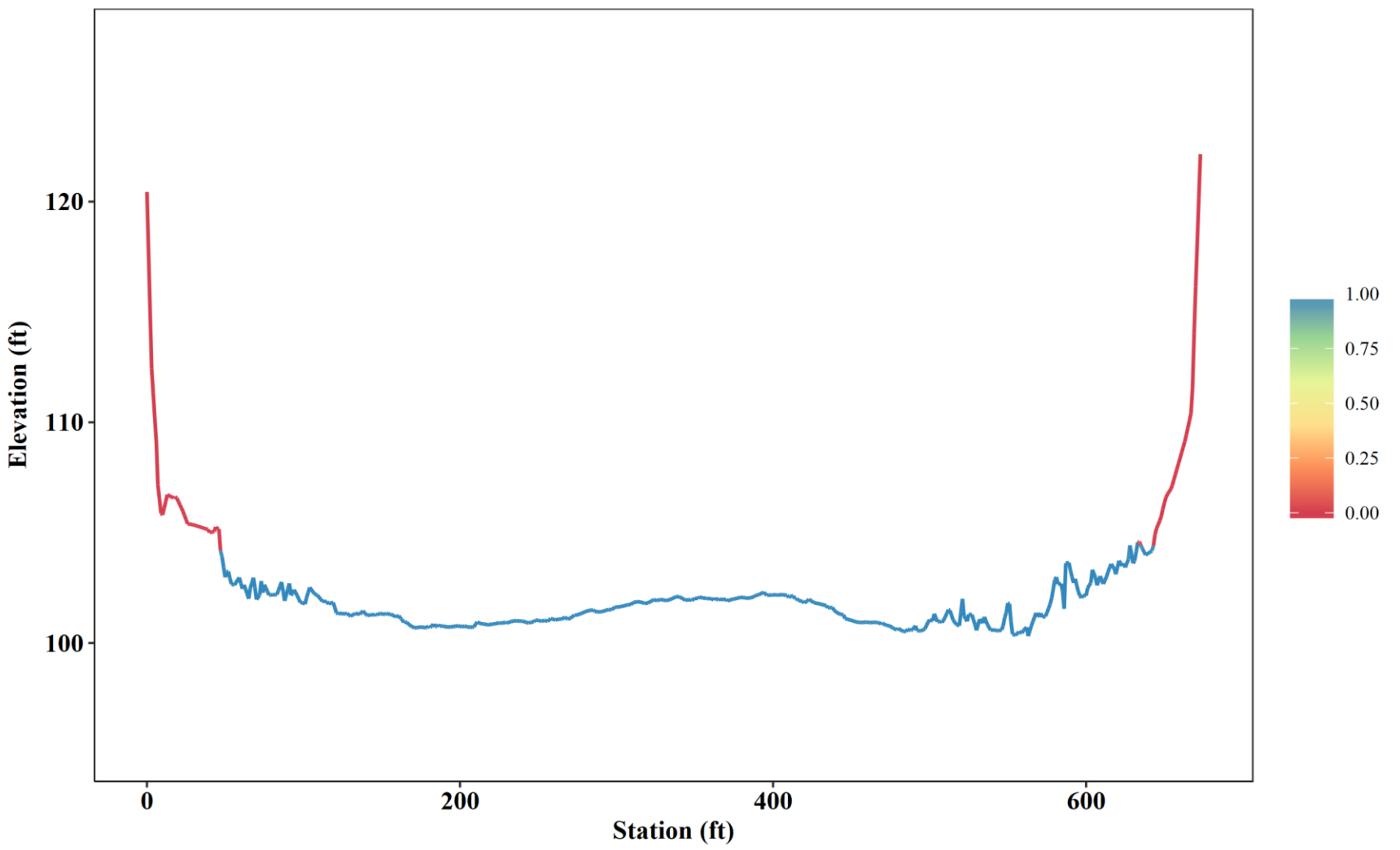

Figure B-17: Persistent Suitable Habitat Available to Proportions of Years for Adult Yellow Lampmussel (1962 through 2003) at T97 during Baseline Operating Conditions.

Note: The colors along the transect profile indicate the proportions of years with persistent habitat available at a given location across the transect.

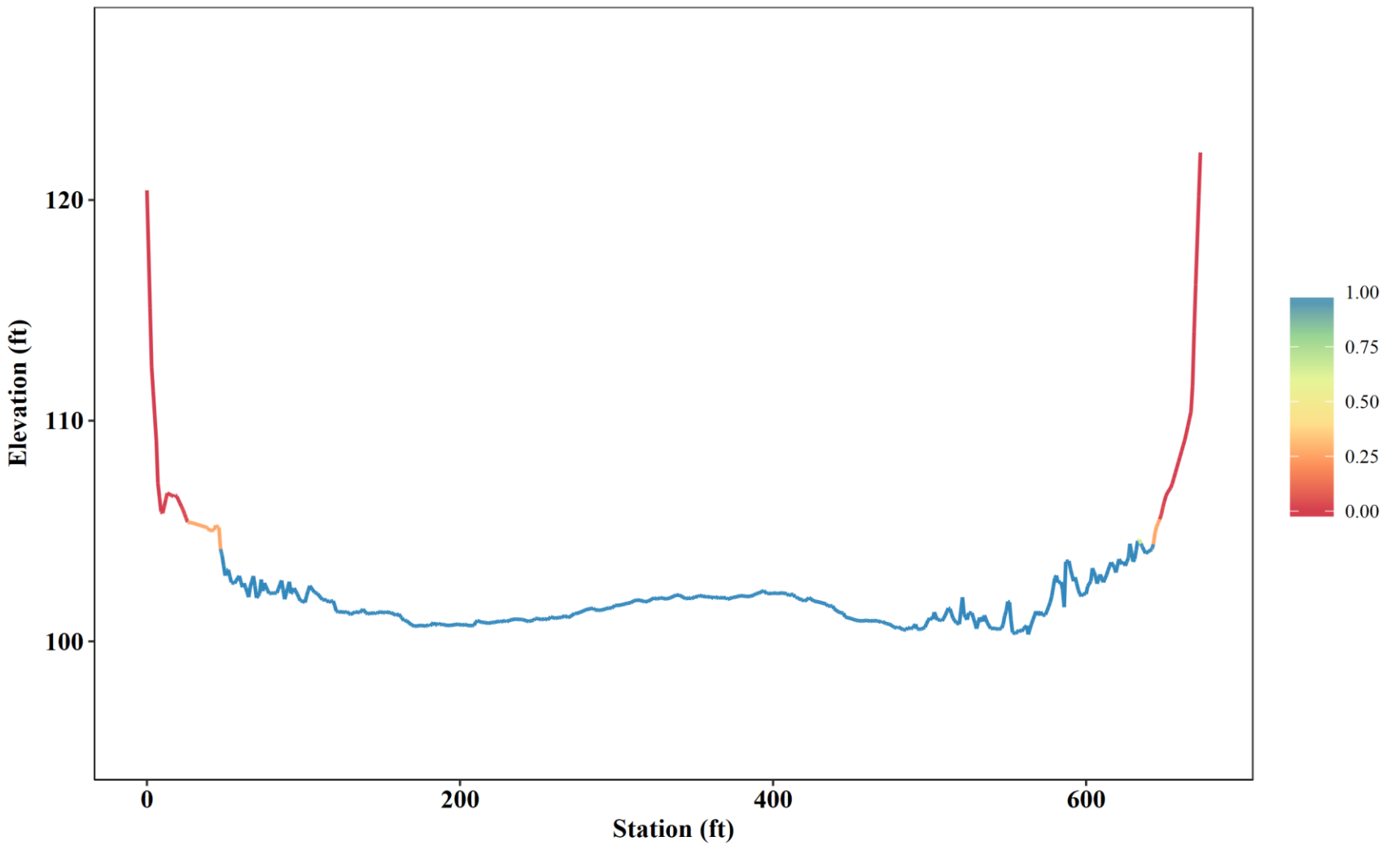

Figure B-18: Persistent Suitable Habitat Available to Proportions of Years for Adult Yellow Lampmussel (1962 through 2003) at T97 during ROR Operating Conditions.

Note: The colors along the transect profile indicate the proportions of years with persistent habitat available at a given location across the transect.

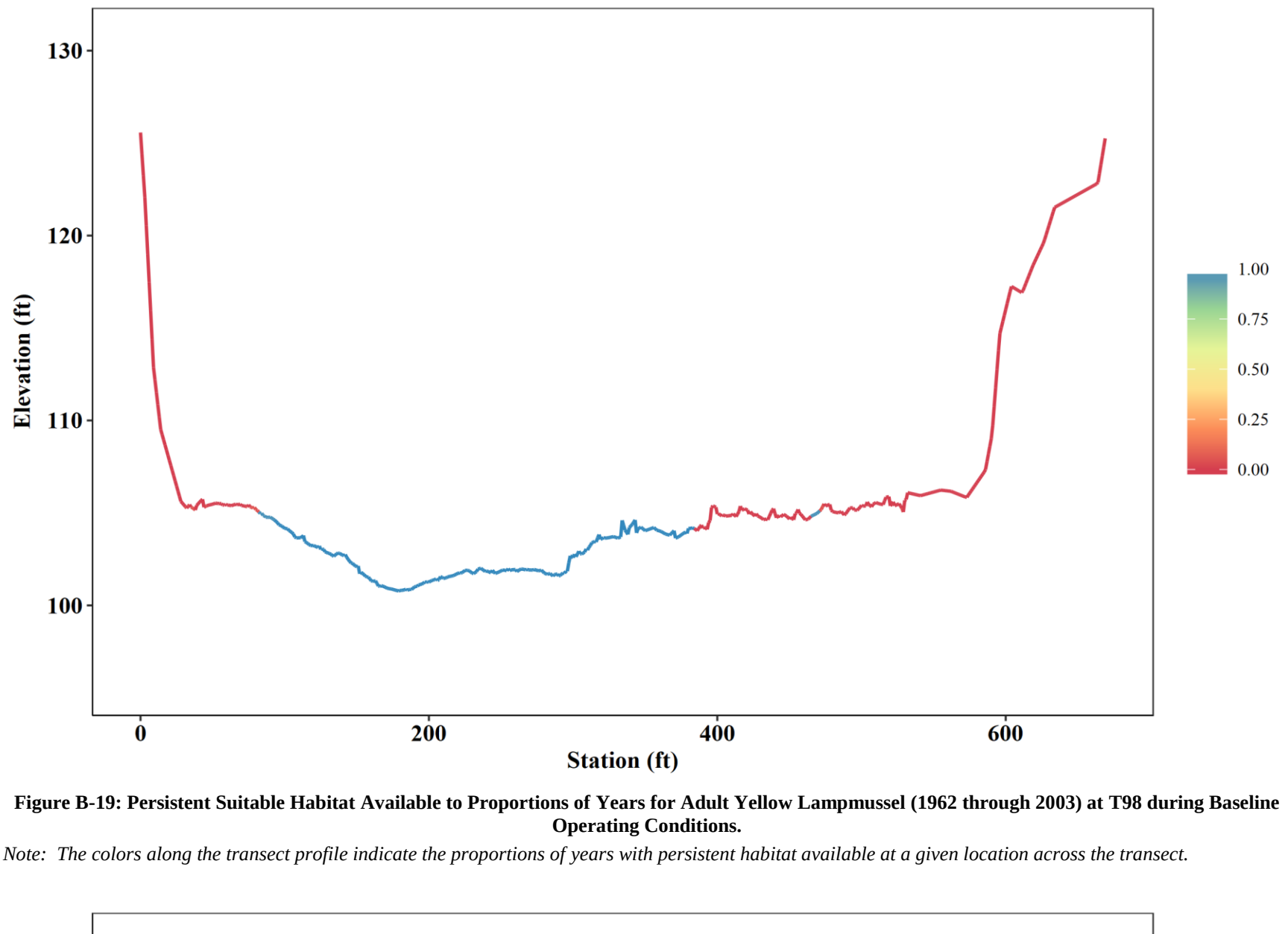

Figure B-19: Persistent Suitable Habitat Available to Proportions of Years for Adult Yellow Lampmussel (1962 through 2003) at T98 during Baseline Operating Conditions.

Note: The colors along the transect profile indicate the proportions of years with persistent habitat available at a given location across the transect.

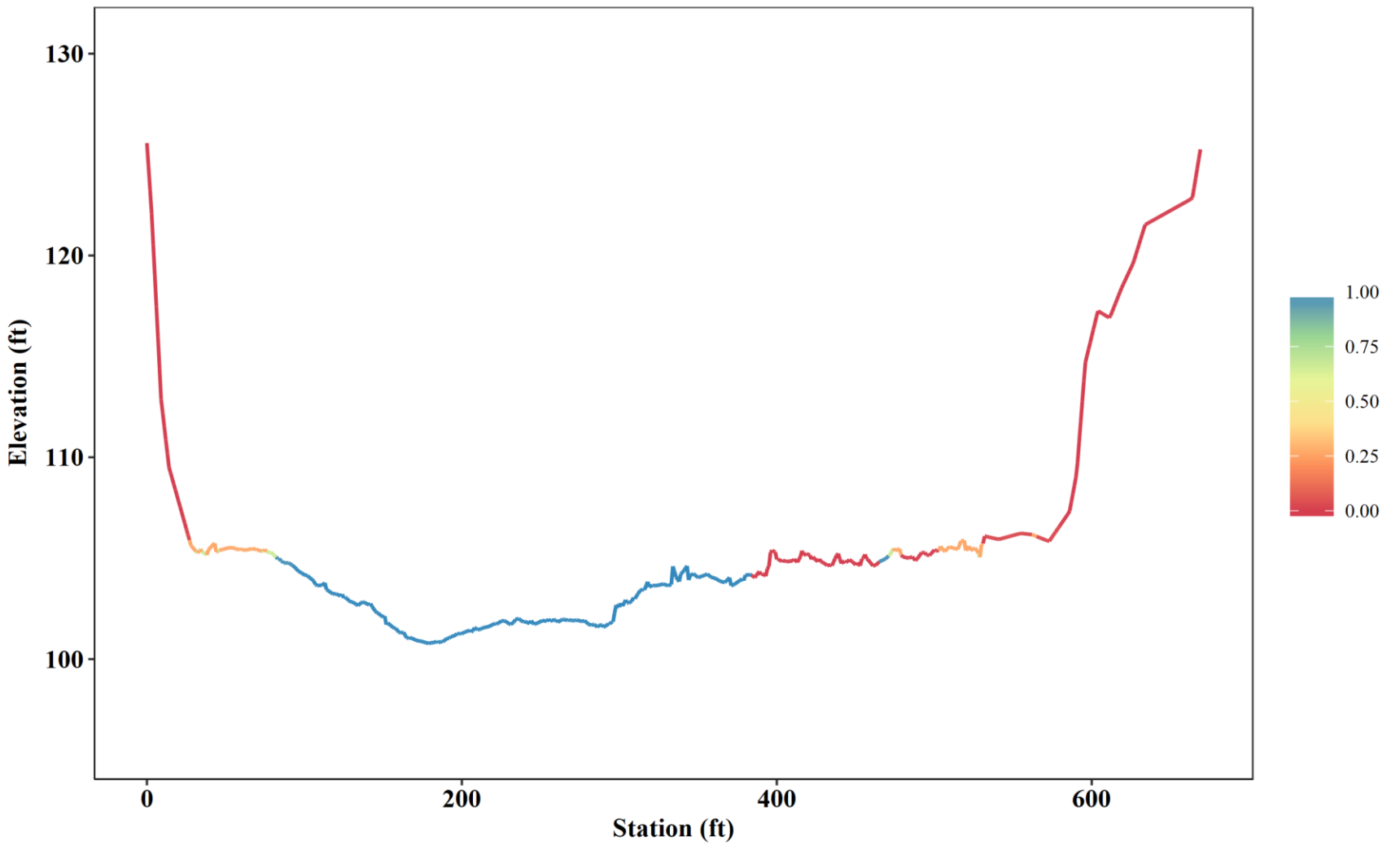

Figure B-20: Persistent Suitable Habitat Available to Proportions of Years for Adult Yellow Lampmussel (1962 through 2003) at T98 during ROR Operating Conditions.

Note: The colors along the transect profile indicate the proportions of years with persistent habitat available at a given location across the transect.

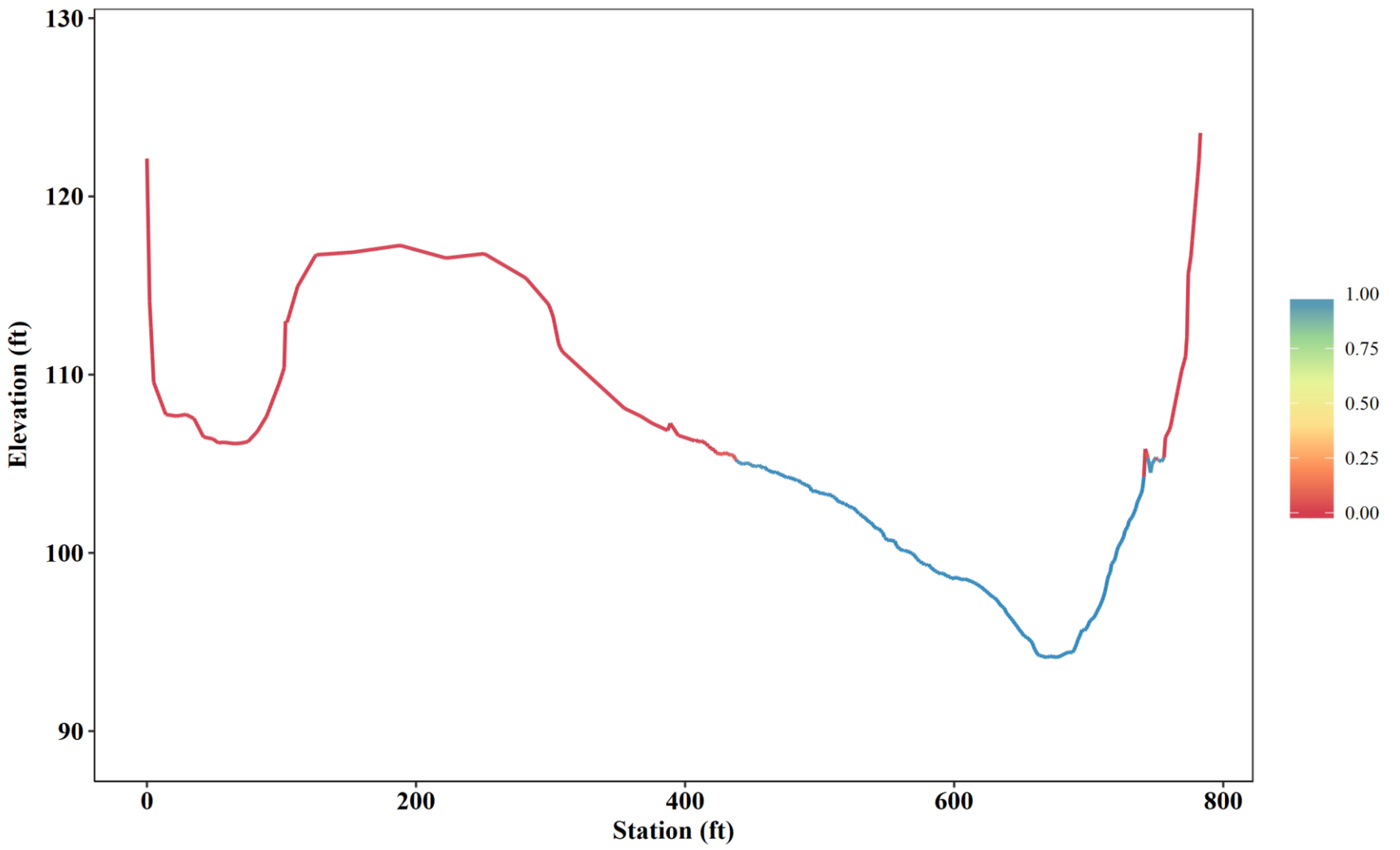

Figure B-21: Persistent Suitable Habitat Available to Proportions of Years for Adult Yellow Lampmussel (1962 through 2003) at T99 during Baseline Operating Conditions.

Note: The colors along the transect profile indicate the proportions of years with persistent habitat available at a given location across the transect.

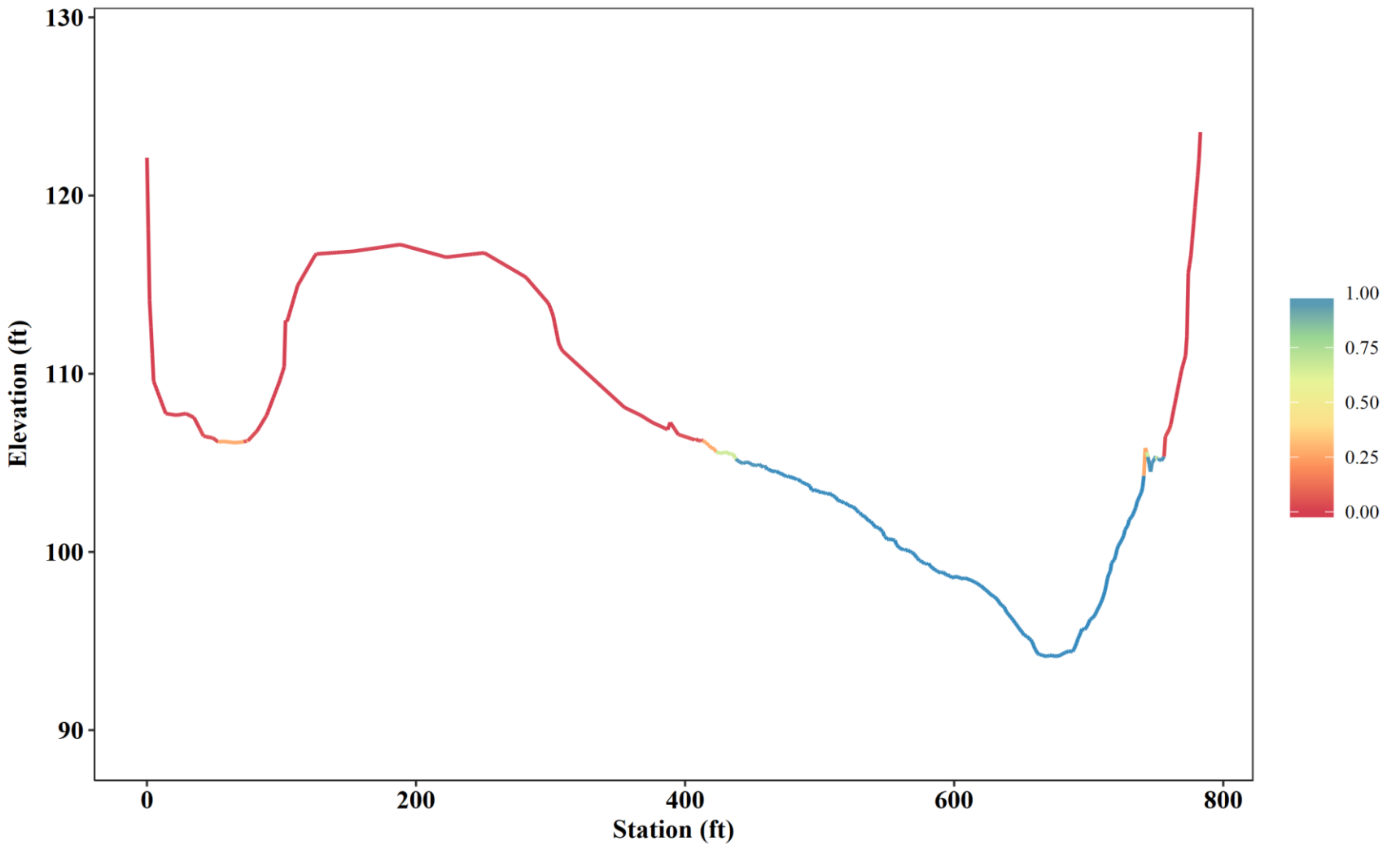

Figure B-22: Persistent Suitable Habitat Available to Proportions of Years for Adult Yellow Lampmussel (1962 through 2003) at T99 during ROR Operating Conditions.

Note: The colors along the transect profile indicate the proportions of years with persistent habitat available at a given location across the transect.

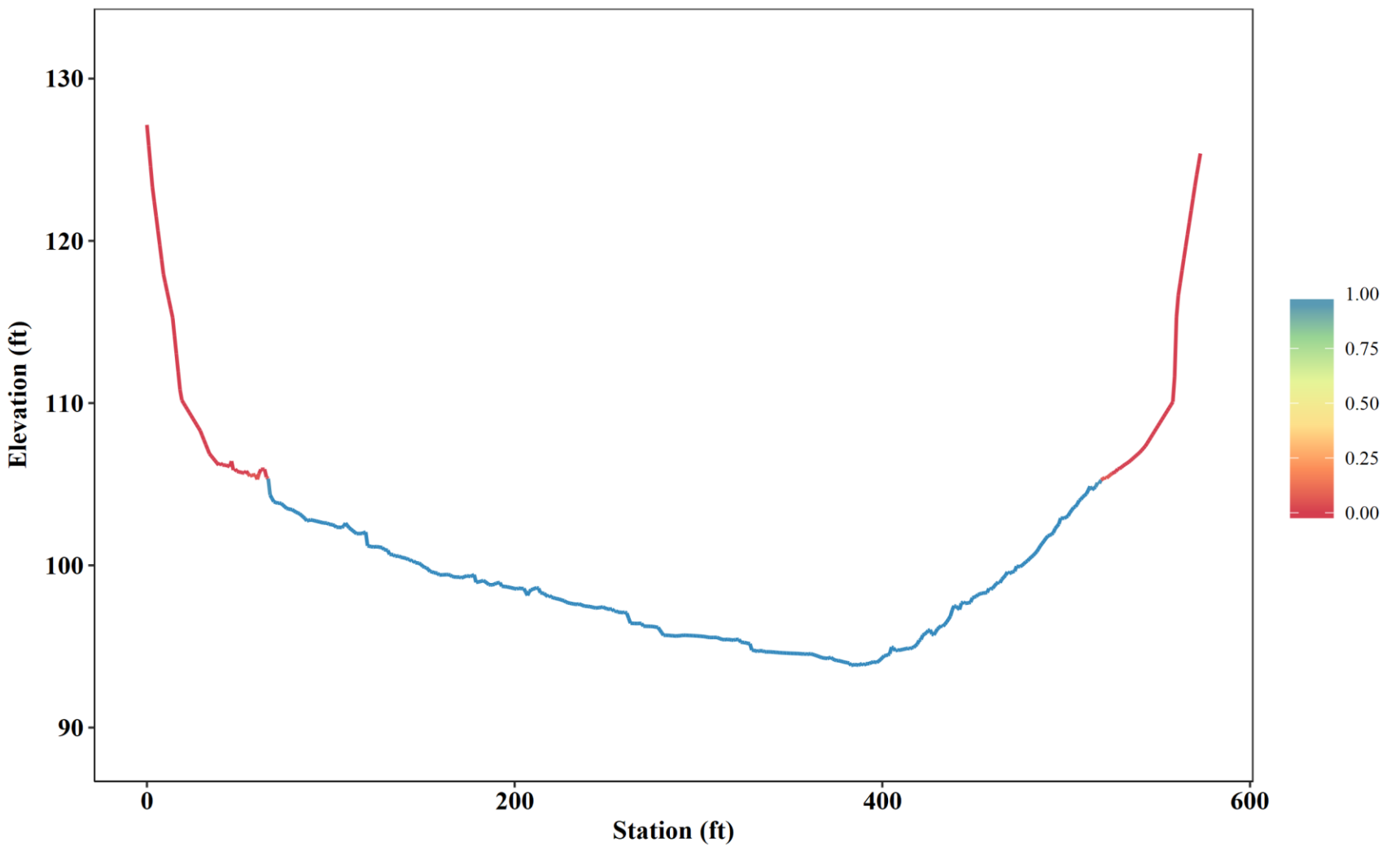

Figure B-23: Persistent Suitable Habitat Available to Proportions of Years for Adult Yellow Lampmussel (1962 through 2003) at T100 during Baseline Operating Conditions.

Note: The colors along the transect profile indicate the proportions of years with persistent habitat available at a given location across the transect.

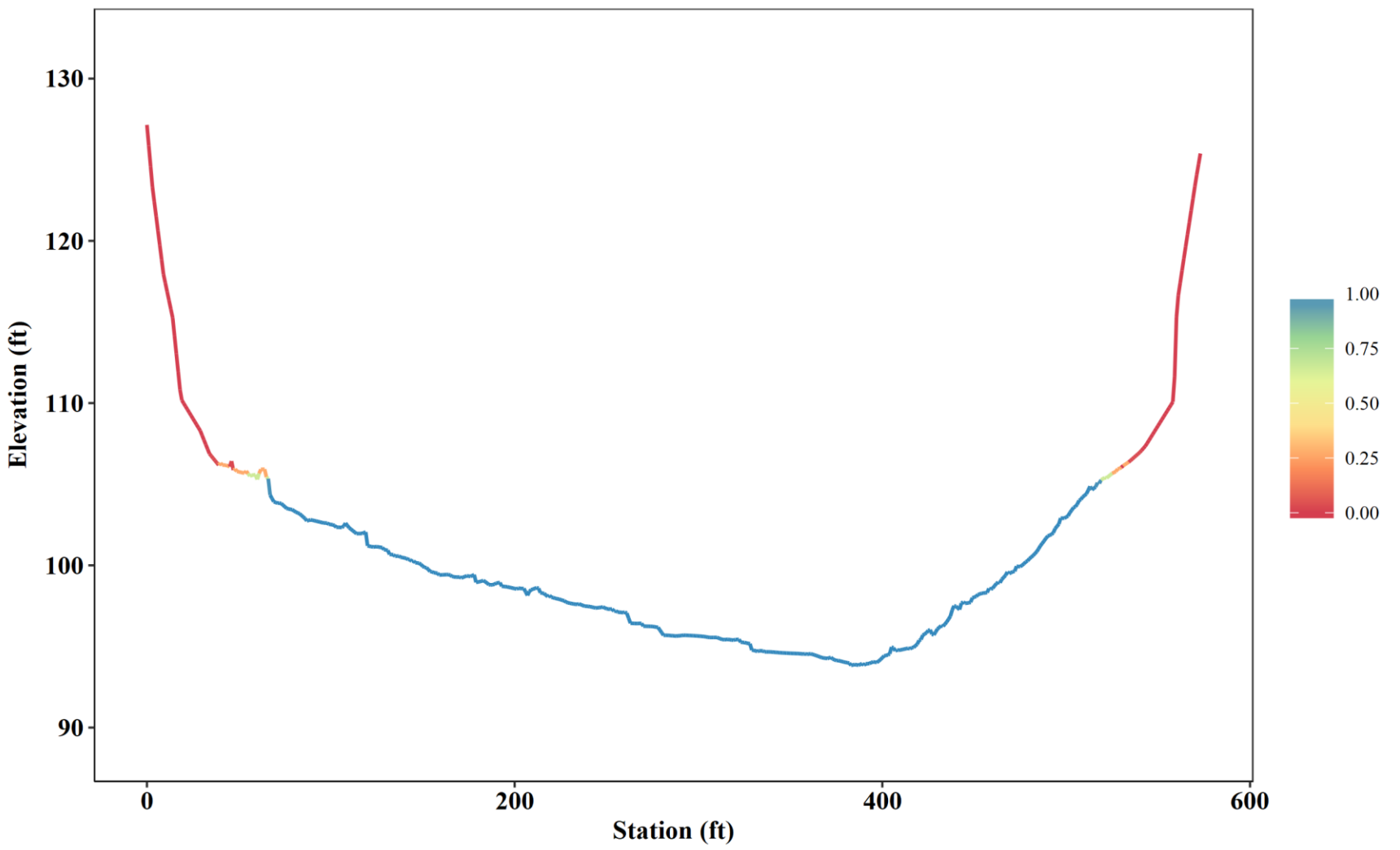

Figure B-24: Persistent Suitable Habitat Available to Proportions of Years for Adult Yellow Lampmussel (1962 through 2003) at T100 during ROR Operating Conditions.

Note: The colors along the transect profile indicate the proportions of years with persistent habitat available at a given location across the transect

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APPENDIX C: BASELINE CONDITIONS – YELLOW LAMPMUSSEL PERSISTENT HABITAT TRANSECT PLOTS – JUVENILE AND ADULT COMPARISON

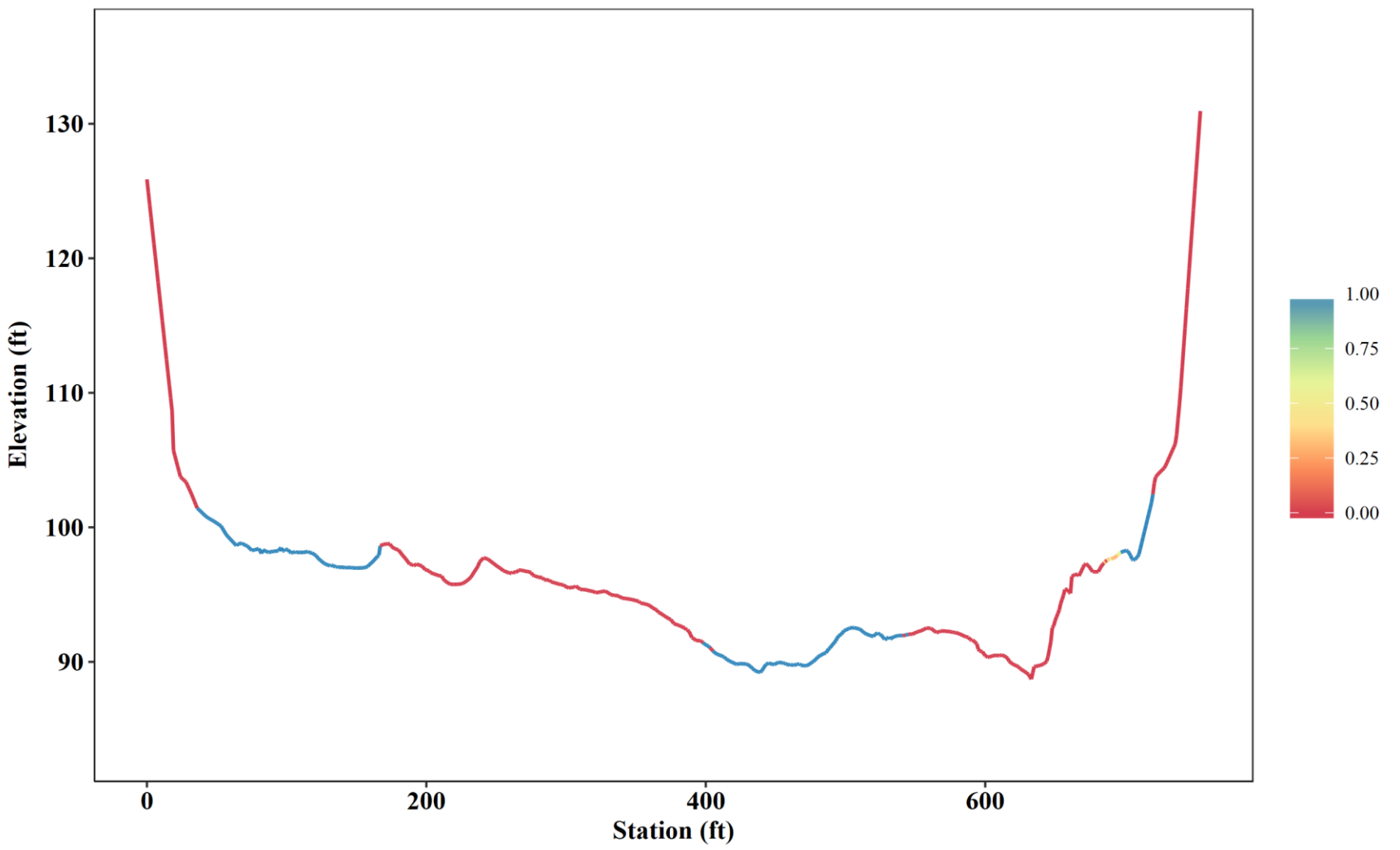

Figure C-1: Persistent Suitable Habitat Available to Proportions of 40 Juvenile Yellow Lampmussel 2-Year Cohorts (1962 through 2003) at T87 during Baseline Operating Conditions.

Note: The colors along the transect profile indicate the proportions of cohorts with persistent habitat available at a given location across the transect.

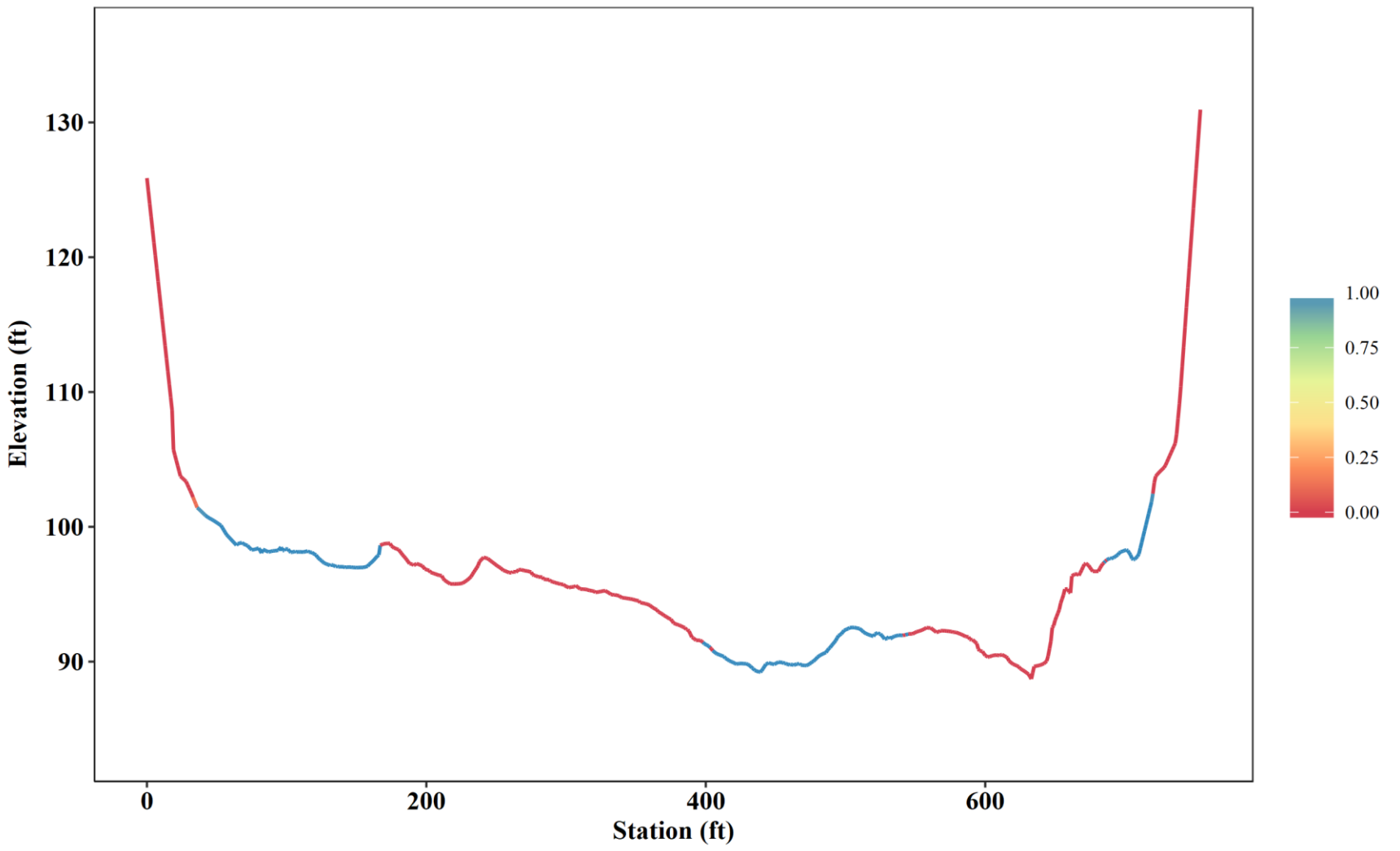

Figure C-2: Persistent Suitable Habitat Available to Proportions of Years for Adult Yellow Lampmussel (1962 through 2003) at T87 during Baseline Operating Conditions.

Note: The colors along the transect profile indicate the proportions of years with persistent habitat available at a given location across the transect.

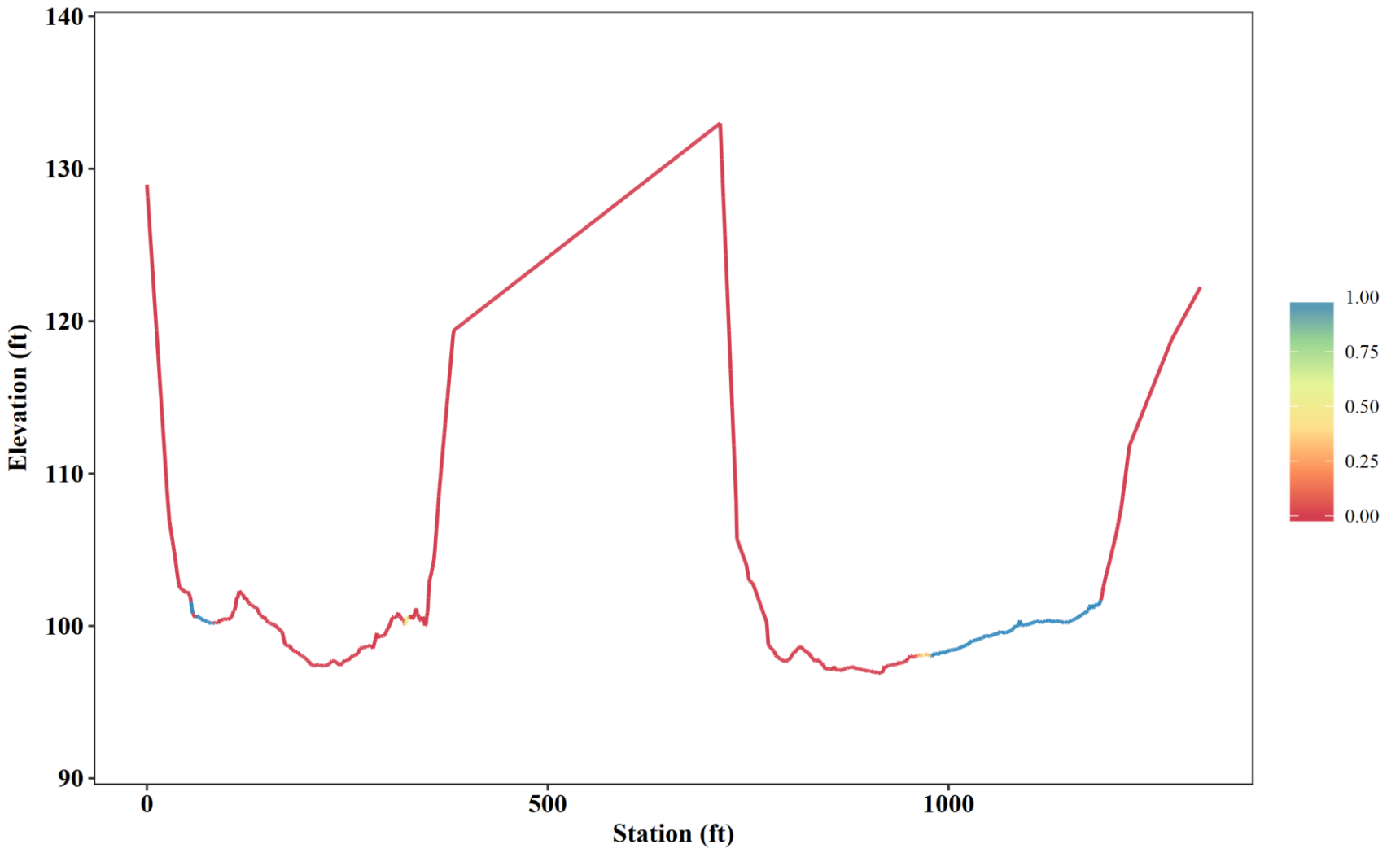

Figure C-3: Persistent Suitable Habitat Available to Proportions of 40 Juvenile Yellow Lampmussel 2-Year Cohorts (1962 through 2003) at T88 during Baseline Operating Conditions.

Note: The colors along the transect profile indicate the proportions of cohorts with persistent habitat available at a given location across the transect.

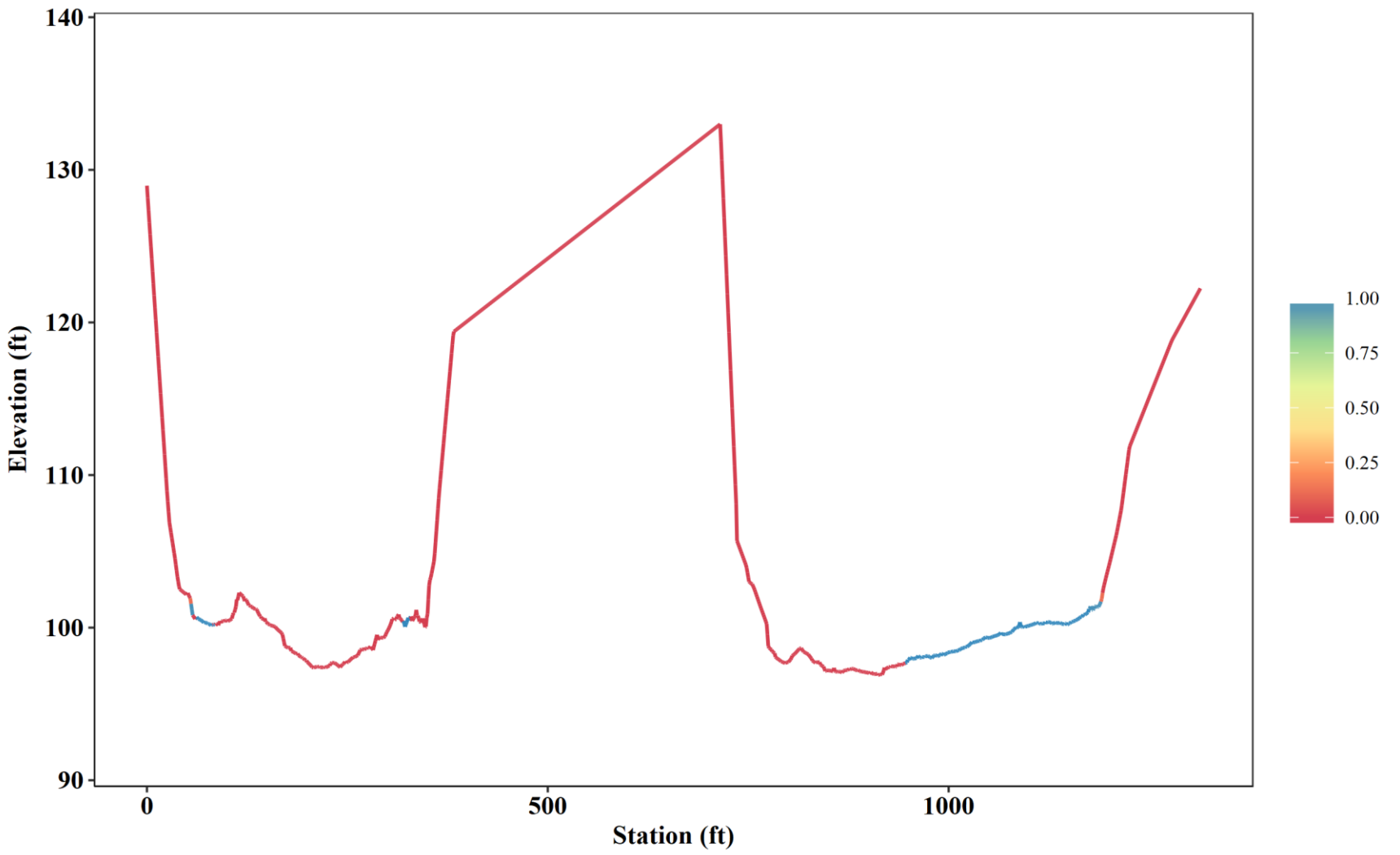

Figure C-4: Persistent Suitable Habitat Available to Proportions of Years for Adult Yellow Lampmussel (1962 through 2003) at T88 during Baseline Operating Conditions.

Note: The colors along the transect profile indicate the proportions of years with persistent habitat available at a given location across the transect.

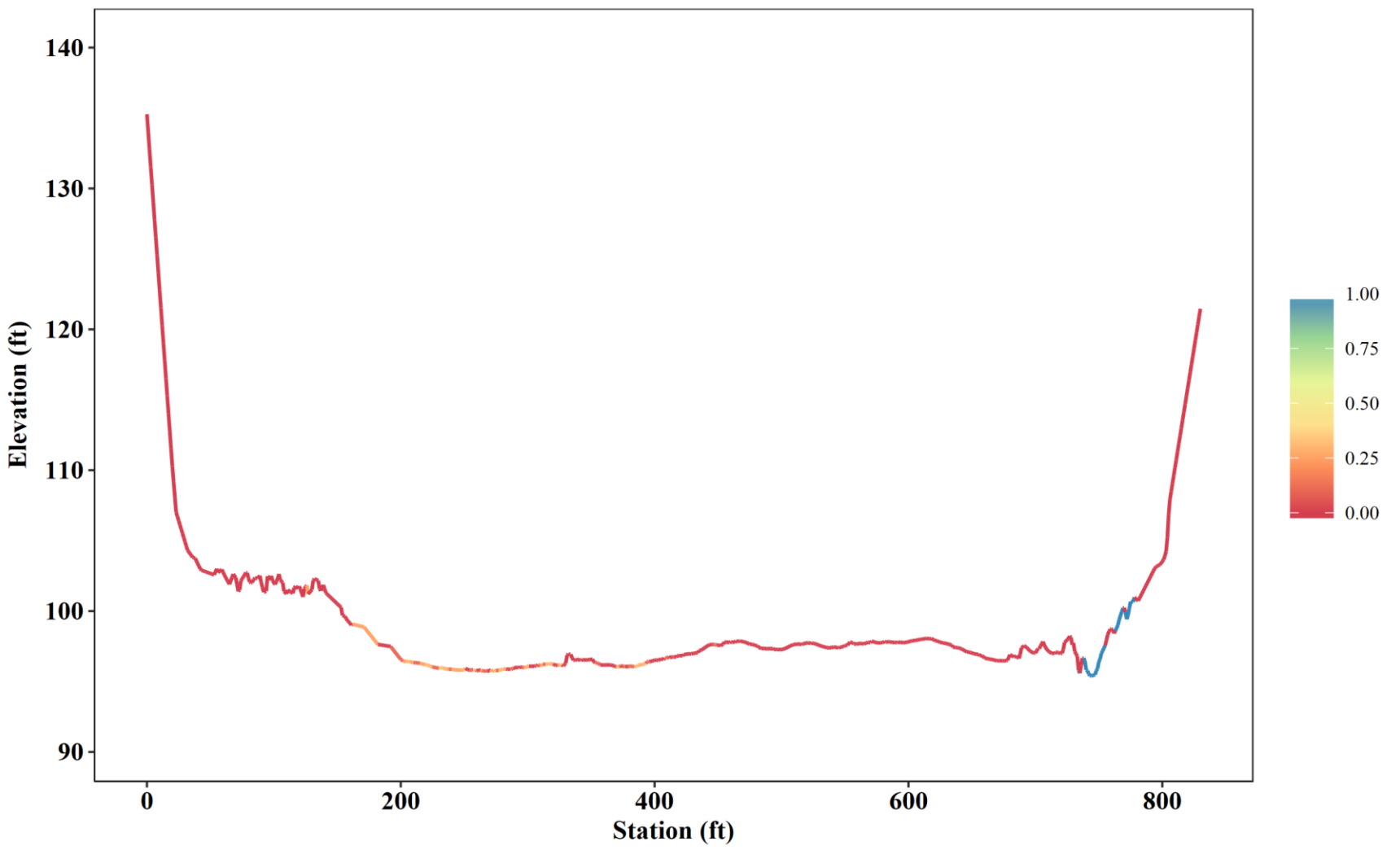

Figure C-5: Persistent Suitable Habitat Available to Proportions of 40 Juvenile Yellow Lampmussel 2-Year Cohorts (1962 through 2003) at T89 during Baseline Operating Conditions.

Note: The colors along the transect profile indicate the proportions of cohorts with persistent habitat available at a given location across the transect.

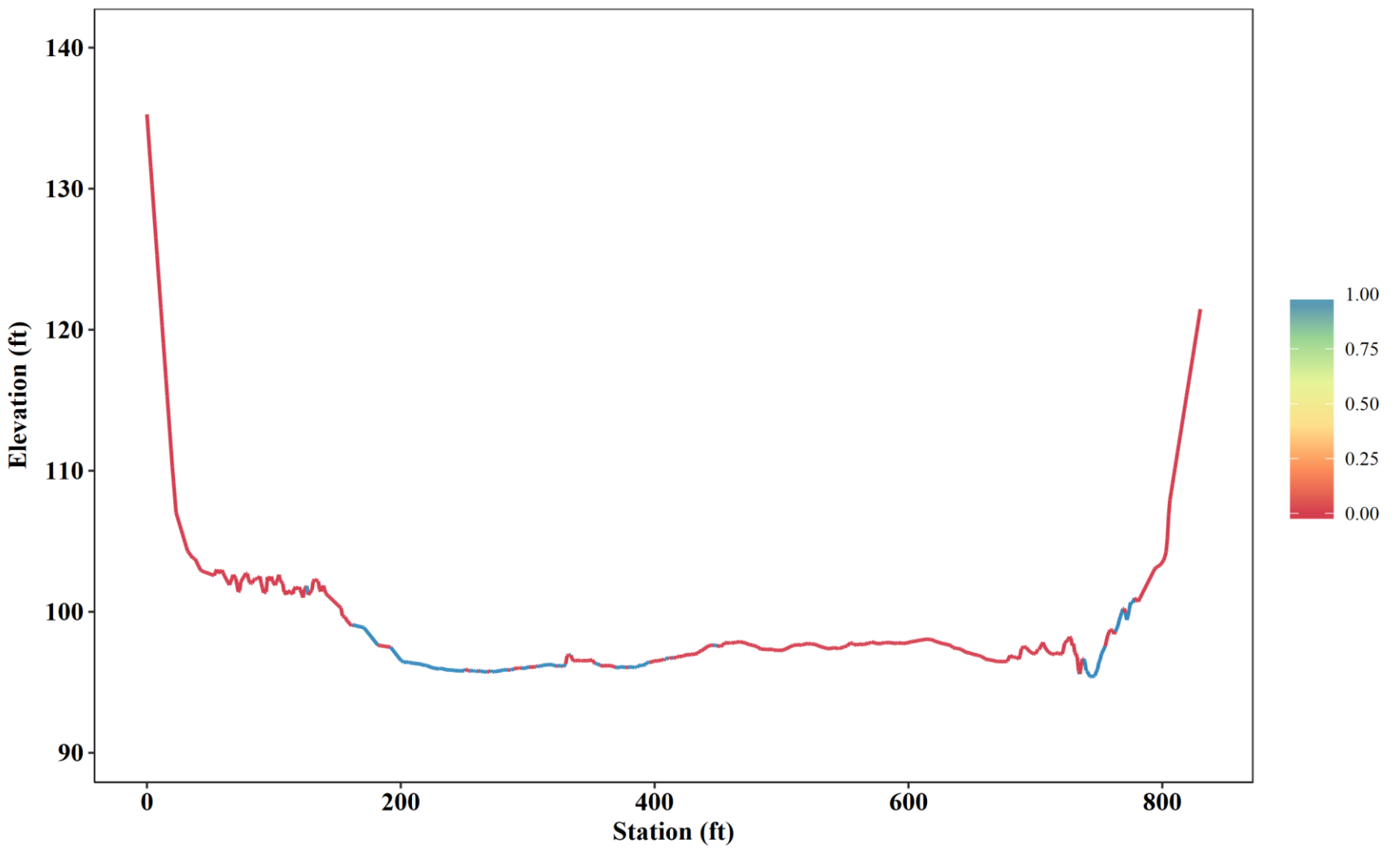

Figure C-6: Persistent Suitable Habitat Available to Proportions of Years for Adult Yellow Lampmussel (1962 through 2003) at T89 during Baseline Operating Conditions.

Note: The colors along the transect profile indicate the proportions of years with persistent habitat available at a given location across the transect.

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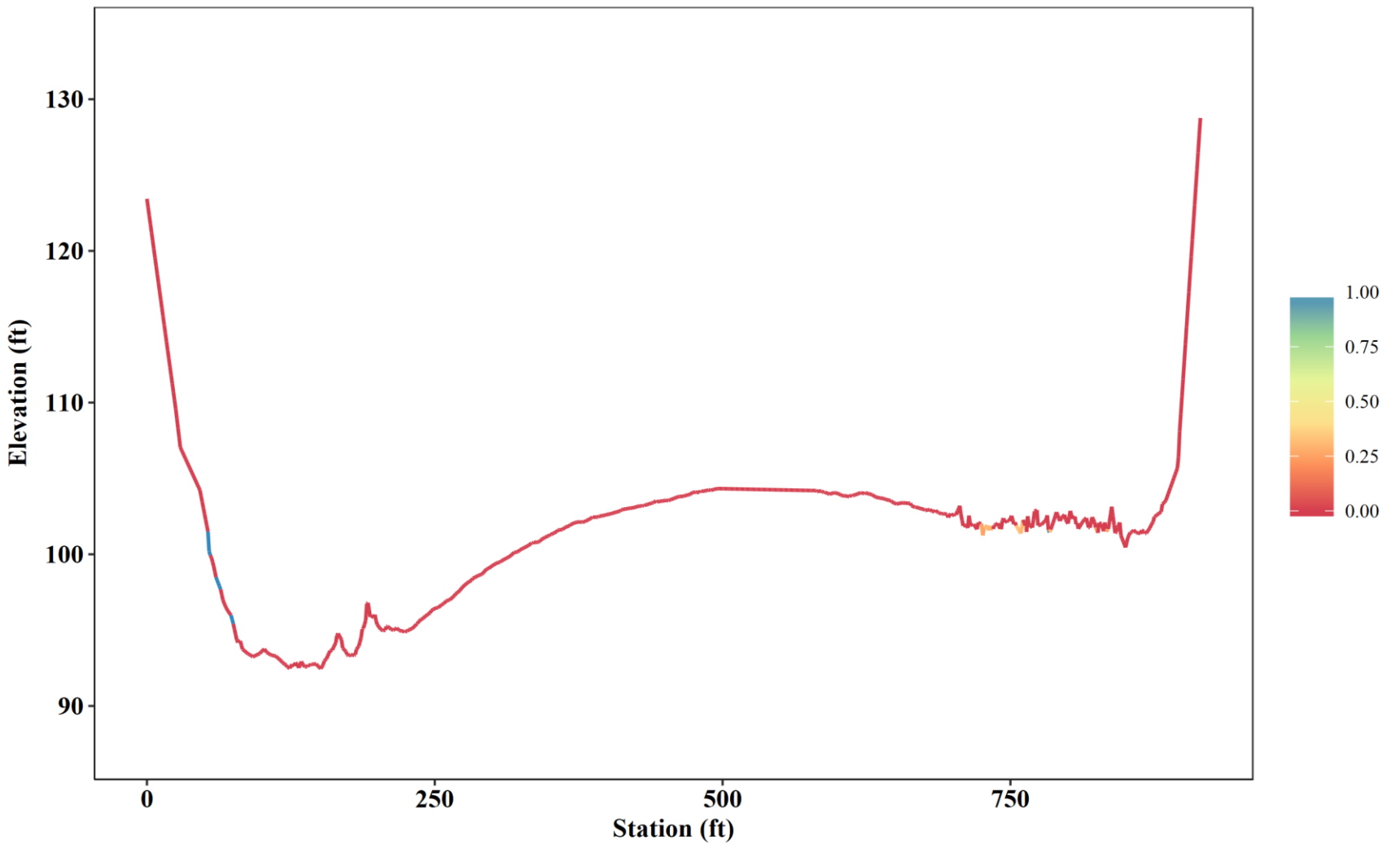

Figure C-7: Persistent Suitable Habitat Available to Proportions of 40 Juvenile Yellow Lampmussel 2-Year Cohorts (1962 through 2003) at T90 during Baseline Operating Conditions.

Note: The colors along the transect profile indicate the proportions of cohorts with persistent habitat available at a given location across the transect.

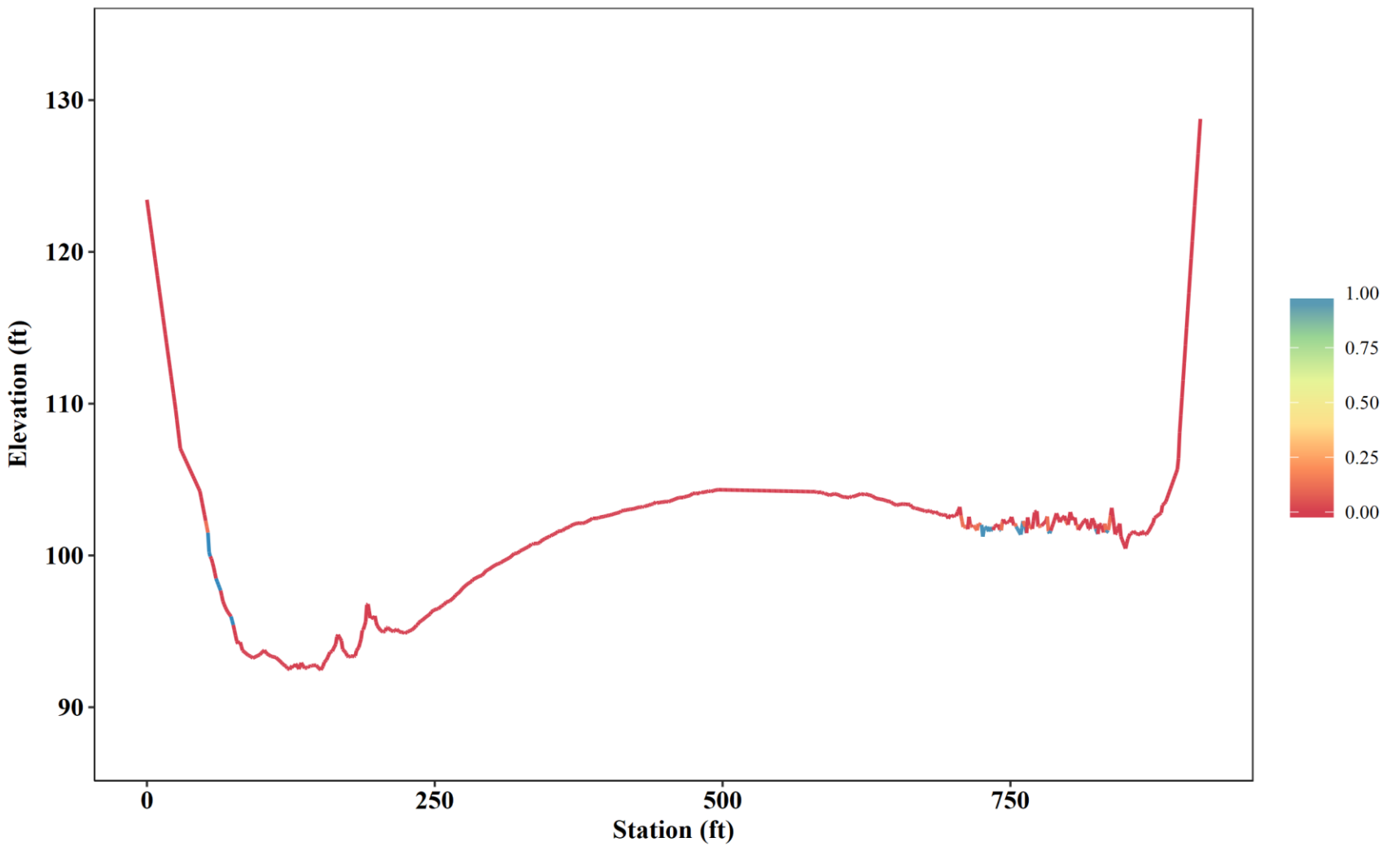

Figure C-8: Persistent Suitable Habitat Available to Proportions of Years for Adult Yellow Lampmussel (1962 through 2003) at T90 during Baseline Operating Conditions.

Note: The colors along the transect profile indicate the proportions of years with persistent habitat available at a given location across the transect.

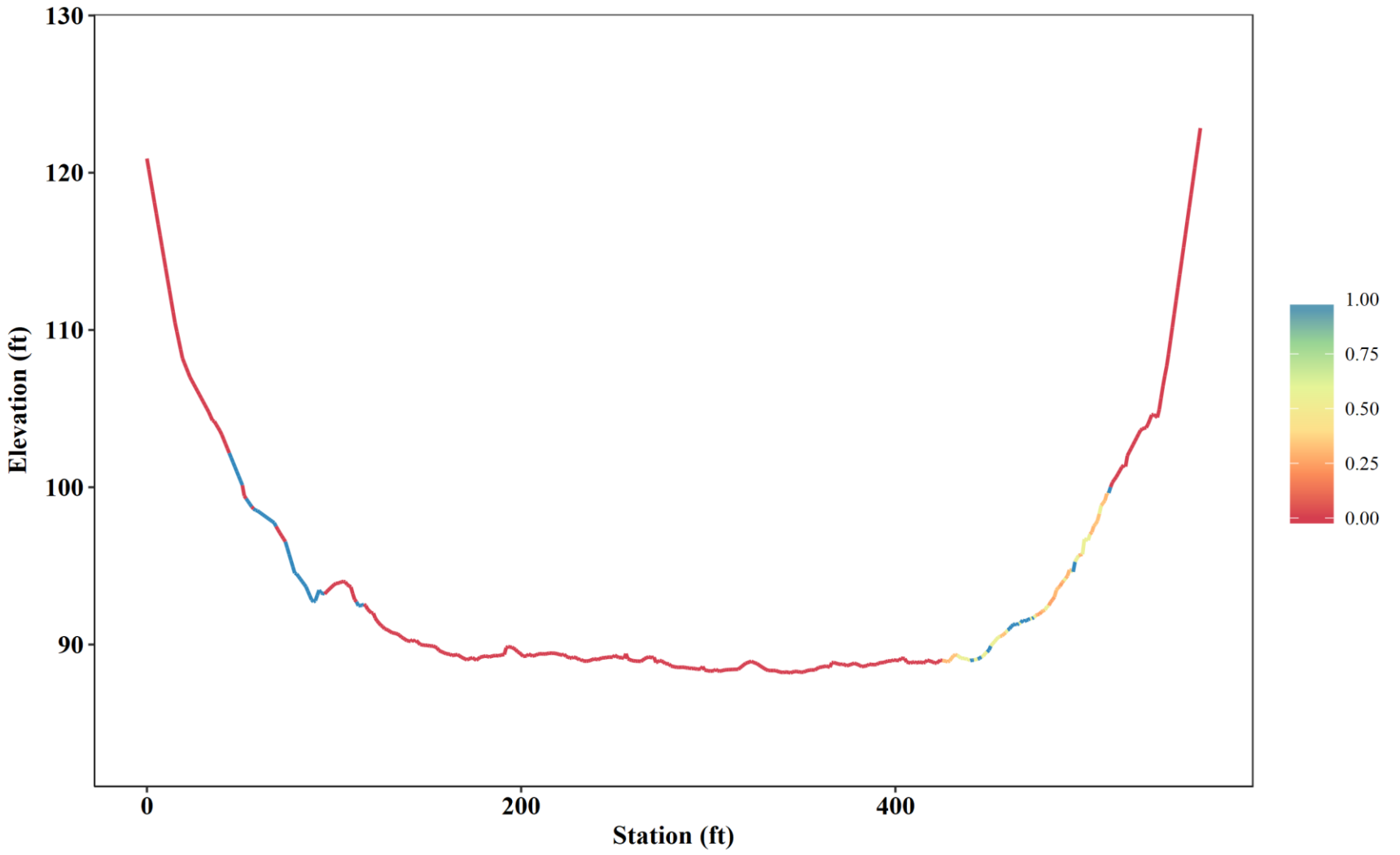

Figure C-9: Persistent Suitable Habitat Available to Proportions of 40 Juvenile Yellow Lampmussel 2-Year Cohorts (1962 through 2003) at T91 during Baseline Operating Conditions.

Note: The colors along the transect profile indicate the proportions of cohorts with persistent habitat available at a given location across the transect.

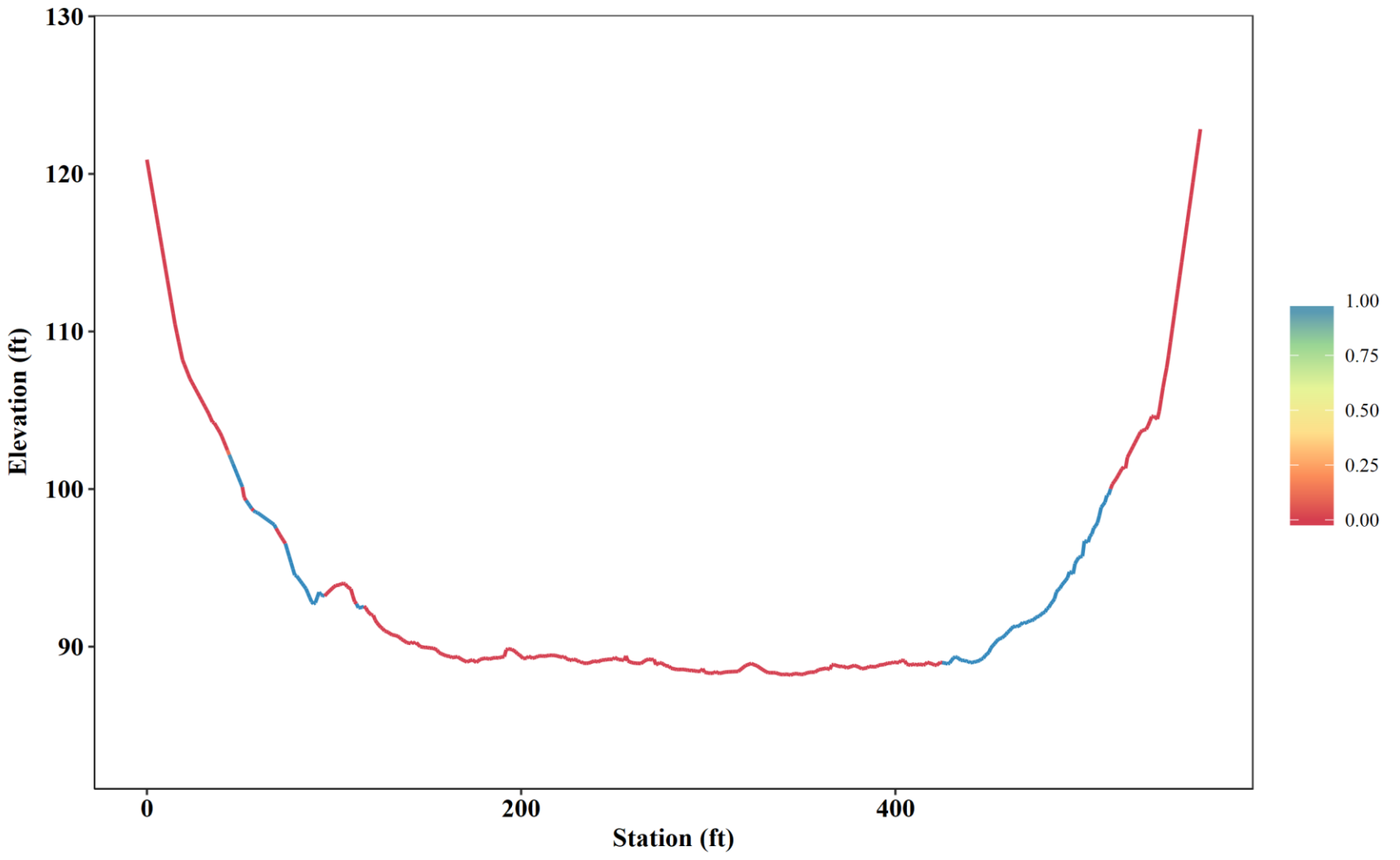

Figure C-10: Persistent Suitable Habitat Available to Proportions of Years for Adult Yellow Lampmussel (1962 through 2003) at T91 during Baseline Operating Conditions.

Note: The colors along the transect profile indicate the proportions of years with persistent habitat available at a given location across the transect.

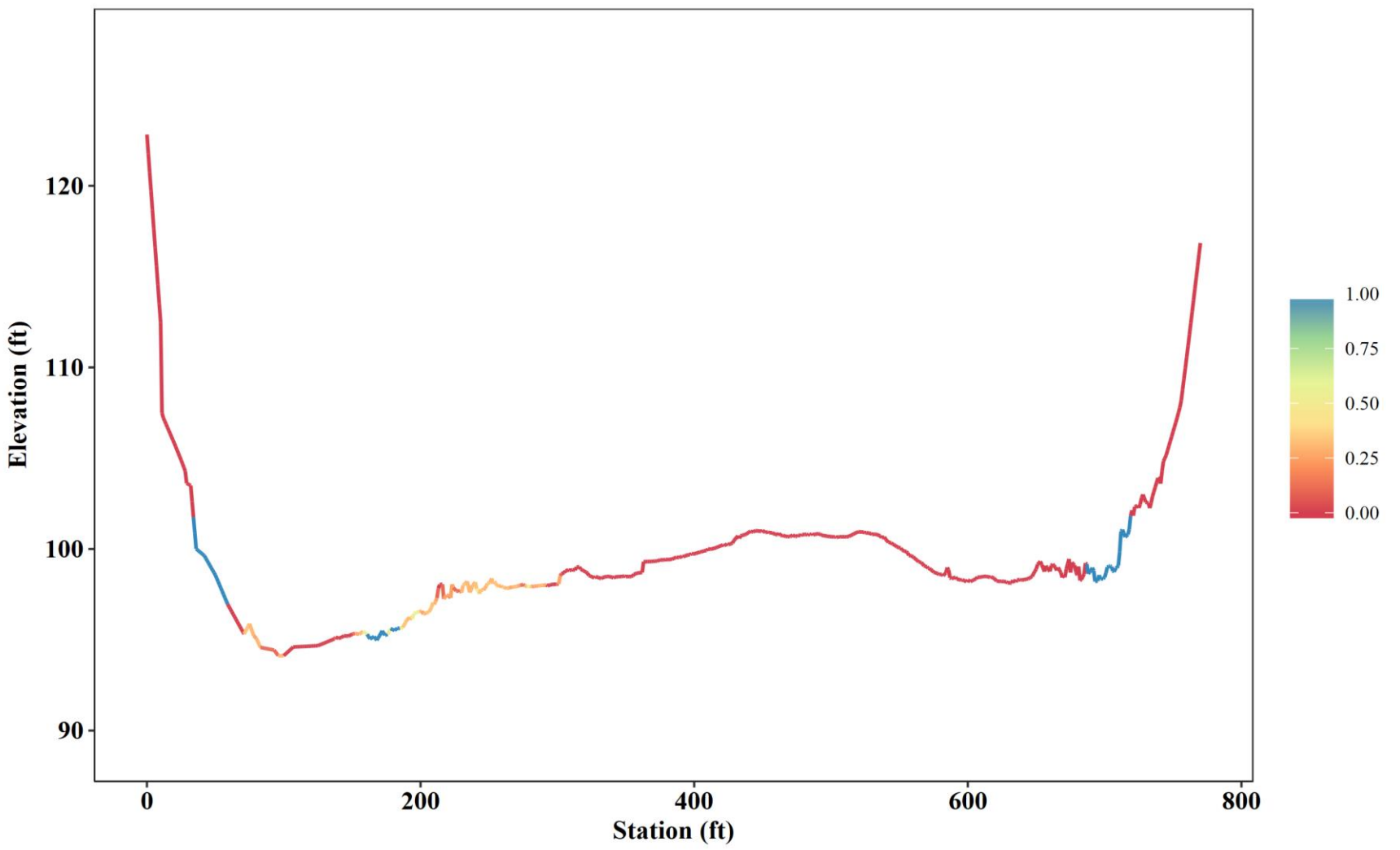

Figure C-11: Persistent Suitable Habitat Available to Proportions of 40 Juvenile Yellow Lampmussel 2-Year Cohorts (1962 through 2003) at T92 during Baseline Operating Conditions.

Note: The colors along the transect profile indicate the proportions of cohorts with persistent habitat available at a given location across the transect.

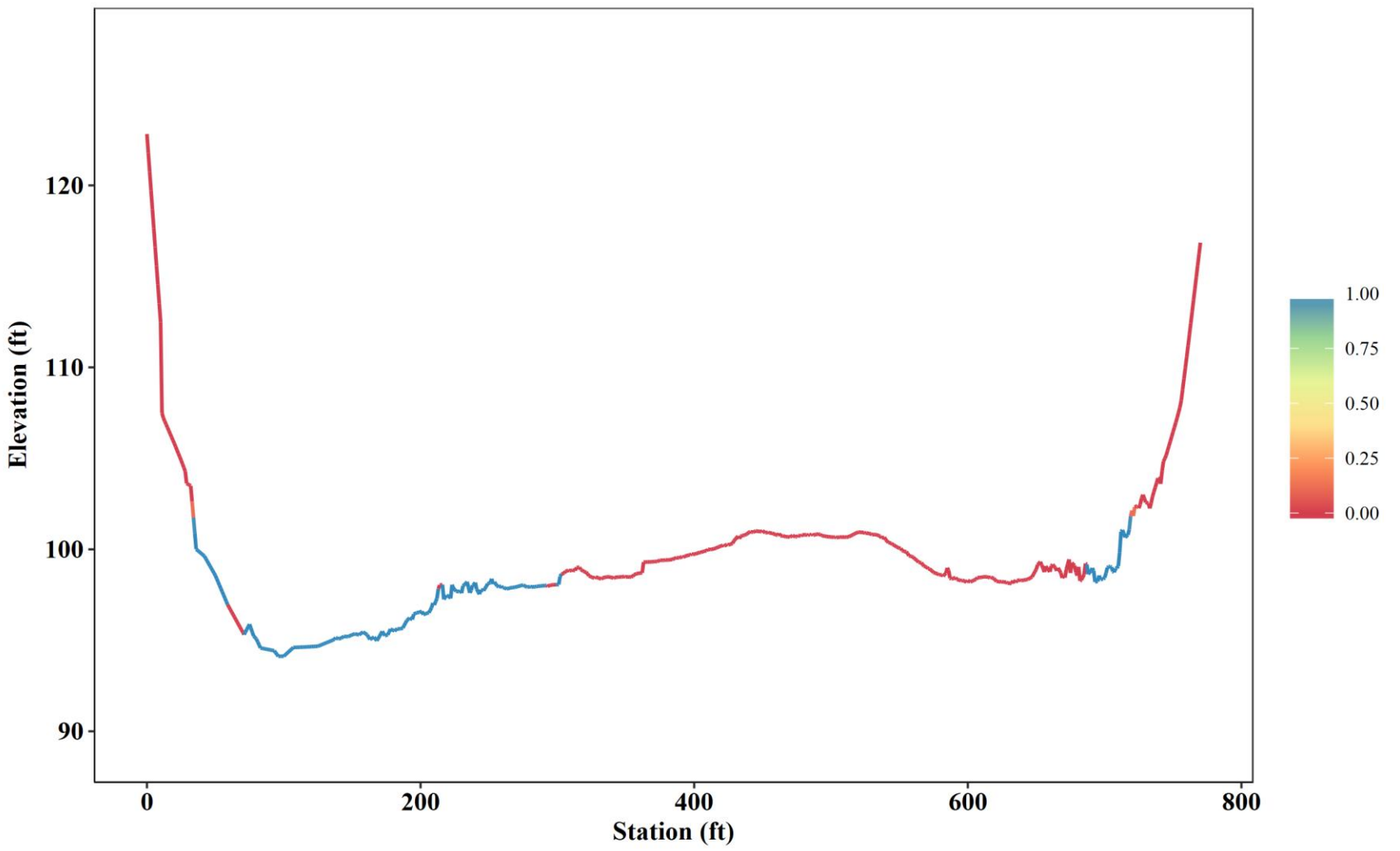

Figure C-12: Persistent Suitable Habitat Available to Proportions of Years for Adult Yellow Lampmussel (1962 through 2003) at T92 during Baseline Operating Conditions.

Note: The colors along the transect profile indicate the proportions of years with persistent habitat available at a given location across the transect.

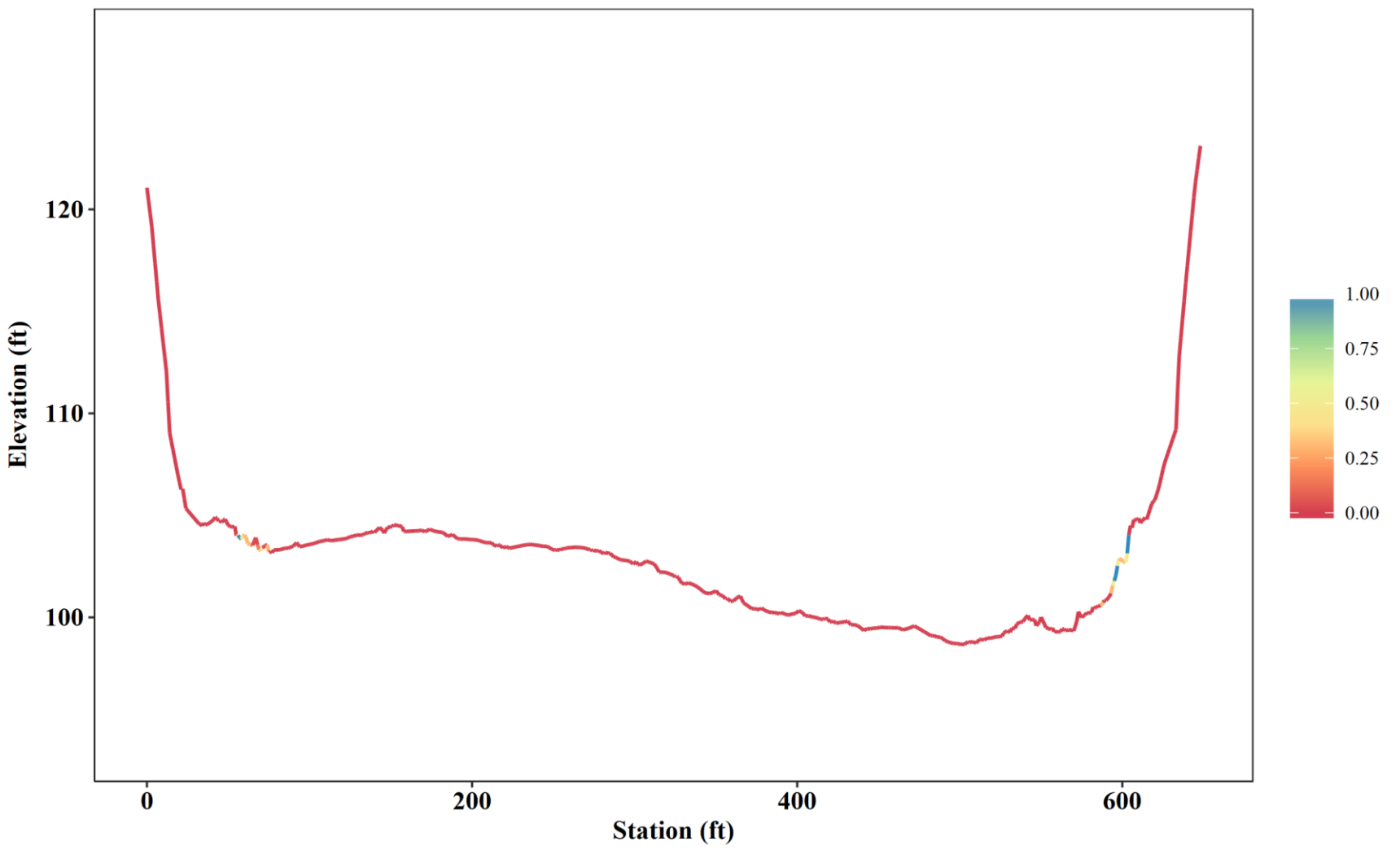

Figure C-13: Persistent Suitable Habitat Available to Proportions of 40 Juvenile Yellow Lampmussel 2-Year Cohorts (1962 through 2003) at T95 during Baseline Operating Conditions.

Note: The colors along the transect profile indicate the proportions of cohorts with persistent habitat available at a given location across the transect.

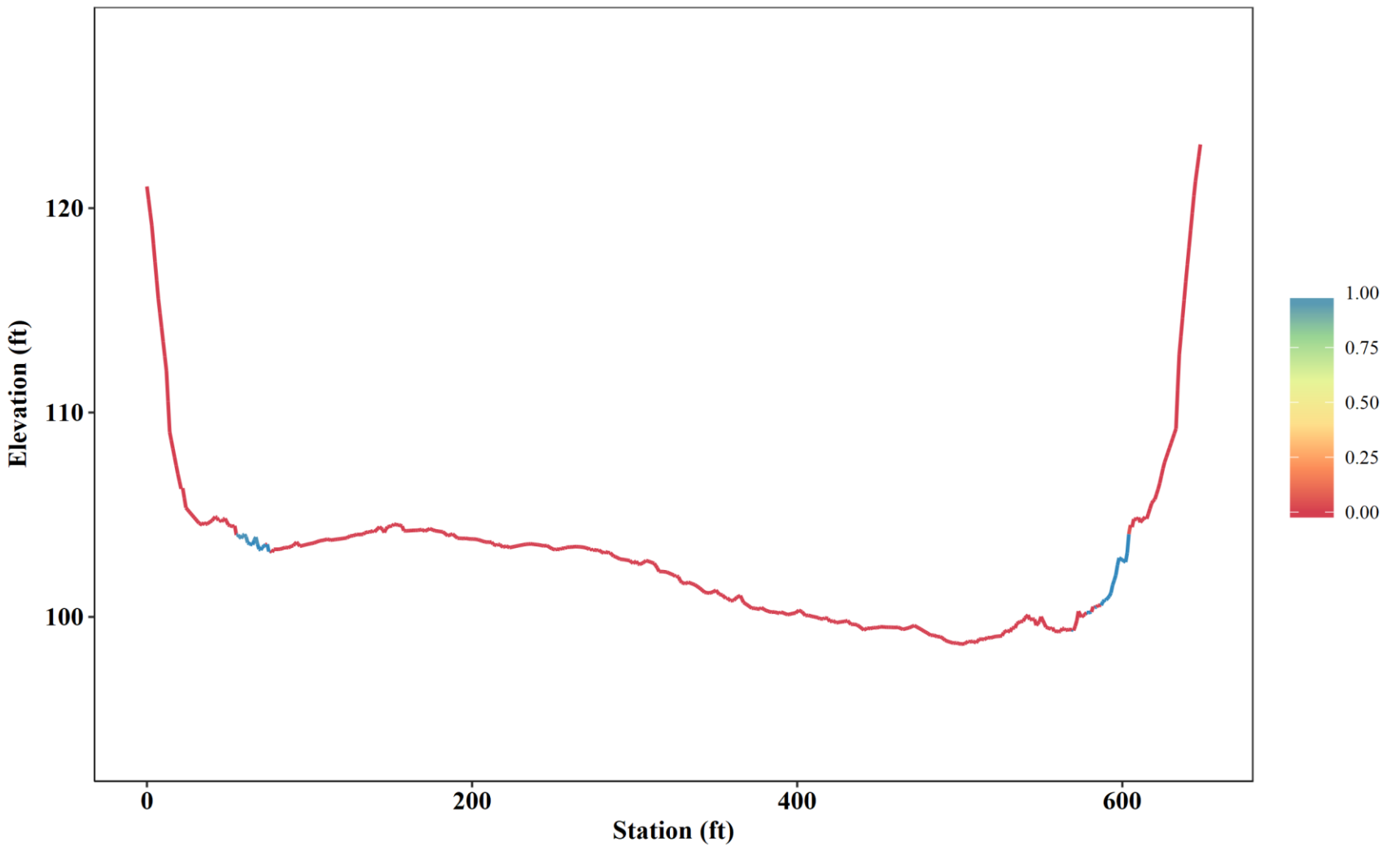

Figure C-14: Persistent Suitable Habitat Available to Proportions of Years for Adult Yellow Lampmussel (1962 through 2003) at T95 during Baseline Operating Conditions.

Note: The colors along the transect profile indicate the proportions of years with persistent habitat available at a given location across the transect.

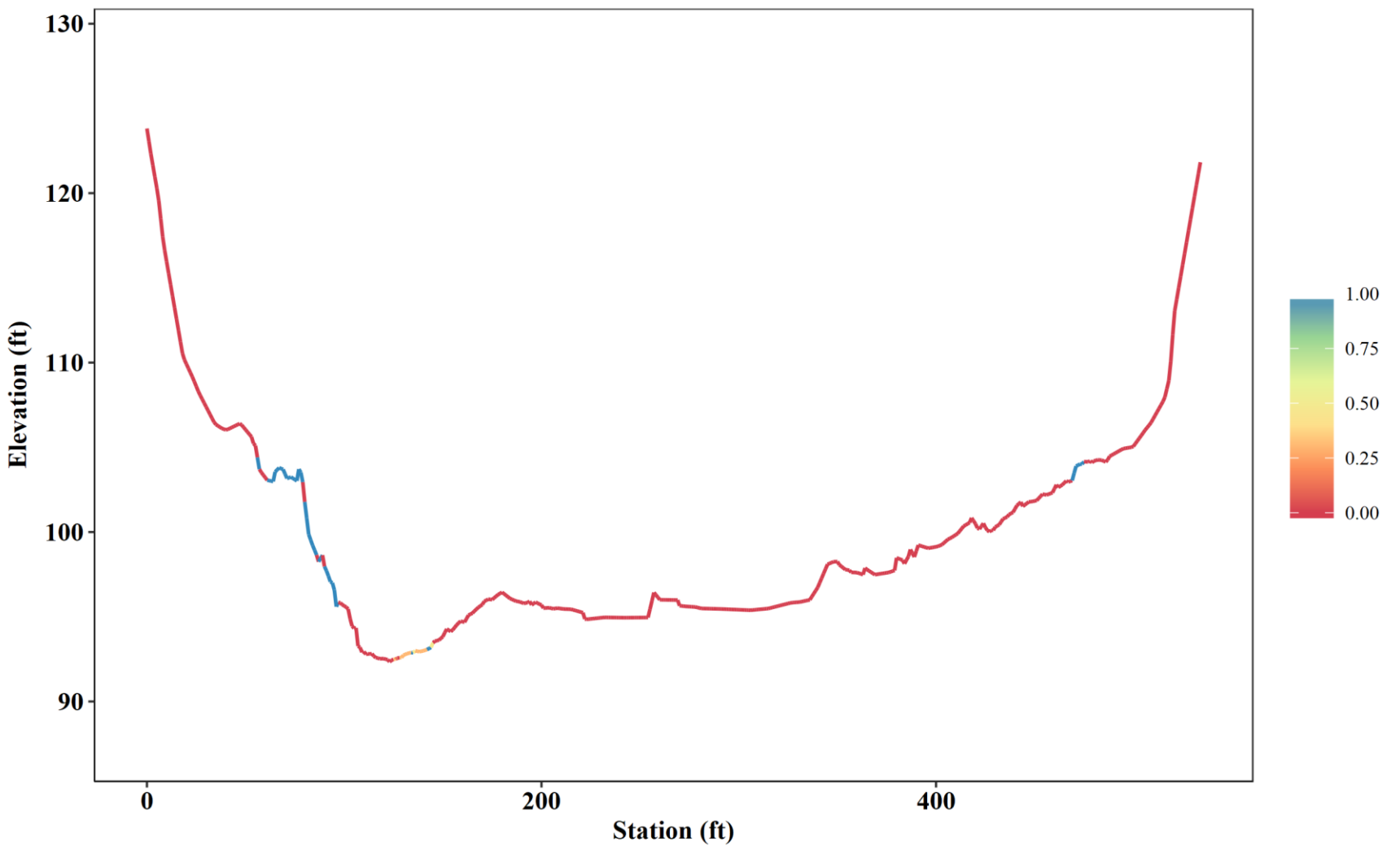

Figure C-15: Persistent Suitable Habitat Available to Proportions of 40 Juvenile Yellow Lampmussel 2-Year Cohorts (1962 through 2003) at T96 during Baseline Operating Conditions.

Note: The colors along the transect profile indicate the proportions of cohorts with persistent habitat available at a given location across the transect.

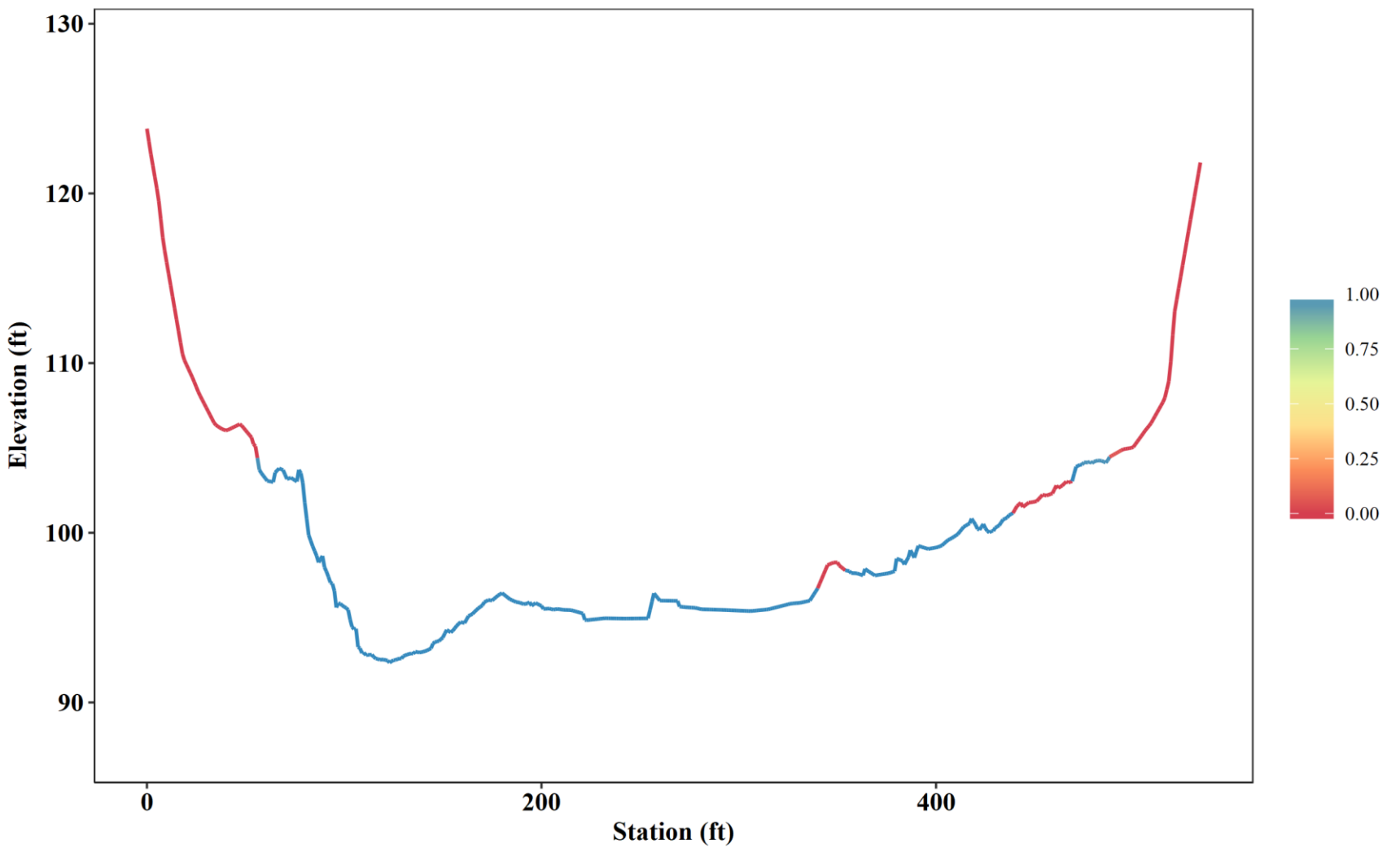

Figure C-16: Persistent Suitable Habitat Available to Proportions of Years for Adult Yellow Lampmussel (1962 through 2003) at T96 during Baseline Operating Conditions.

Note: The colors along the transect profile indicate the proportions of years with persistent habitat available at a given location across the transect.

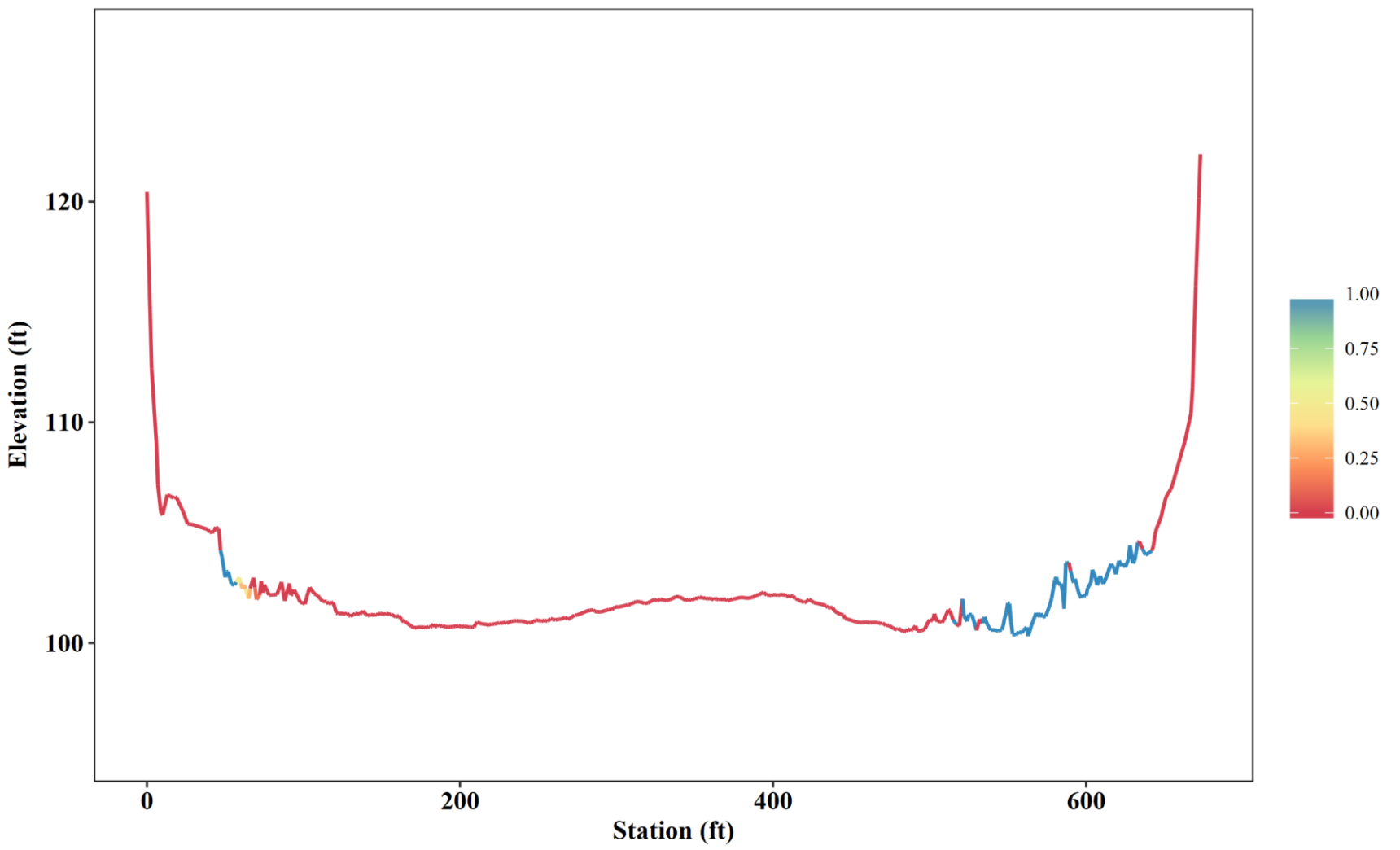

Figure C-17: Persistent Suitable Habitat Available to Proportions of 40 Juvenile Yellow Lampmussel 2-Year Cohorts (1962 through 2003) at T97 during Baseline Operating Conditions.

Note: The colors along the transect profile indicate the proportions of cohorts with persistent habitat available at a given location across the transect.

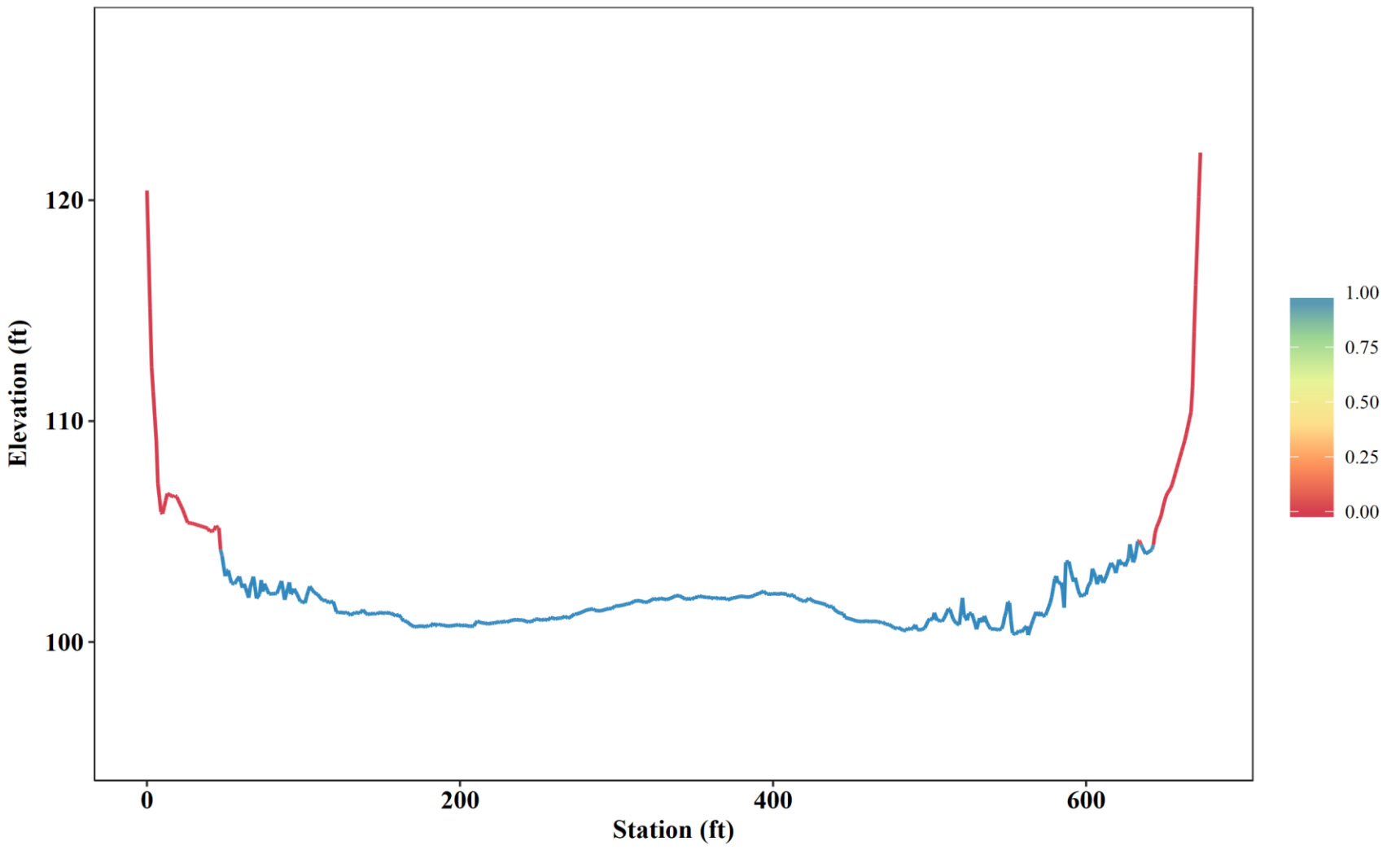

Figure C-18: Persistent Suitable Habitat Available to Proportions of Years for Adult Yellow Lampmussel (1962 through 2003) at T97 during Baseline Operating Conditions.

Note: The colors along the transect profile indicate the proportions of years with persistent habitat available at a given location across the transect.

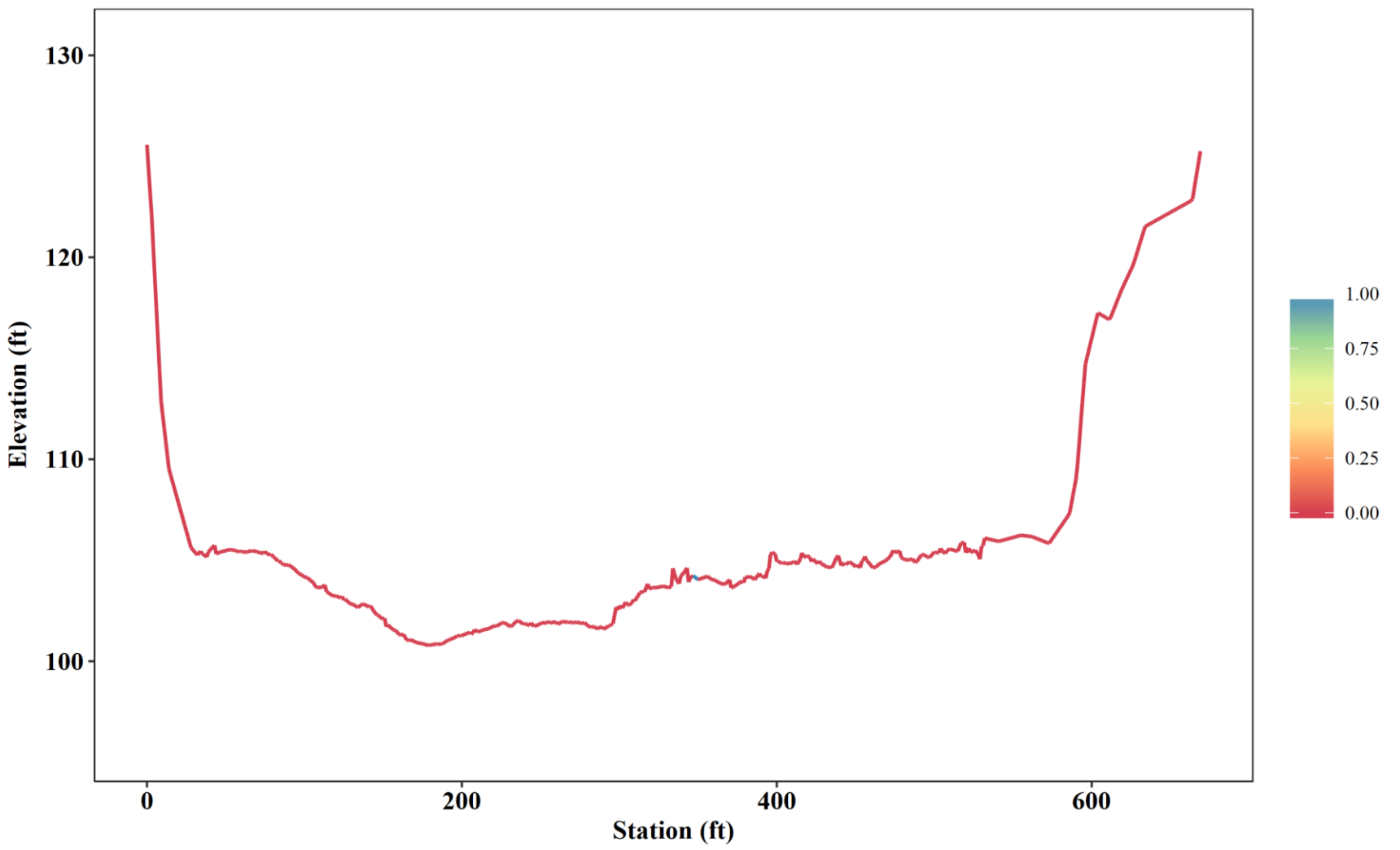

Figure C-19: Persistent Suitable Habitat Available to Proportions of 40 Juvenile Yellow Lampmussel 2-Year Cohorts (1962 through 2003) at T98 during Baseline Operating Conditions.

Note: The colors along the transect profile indicate the proportions of cohorts with persistent habitat available at a given location across the transect.

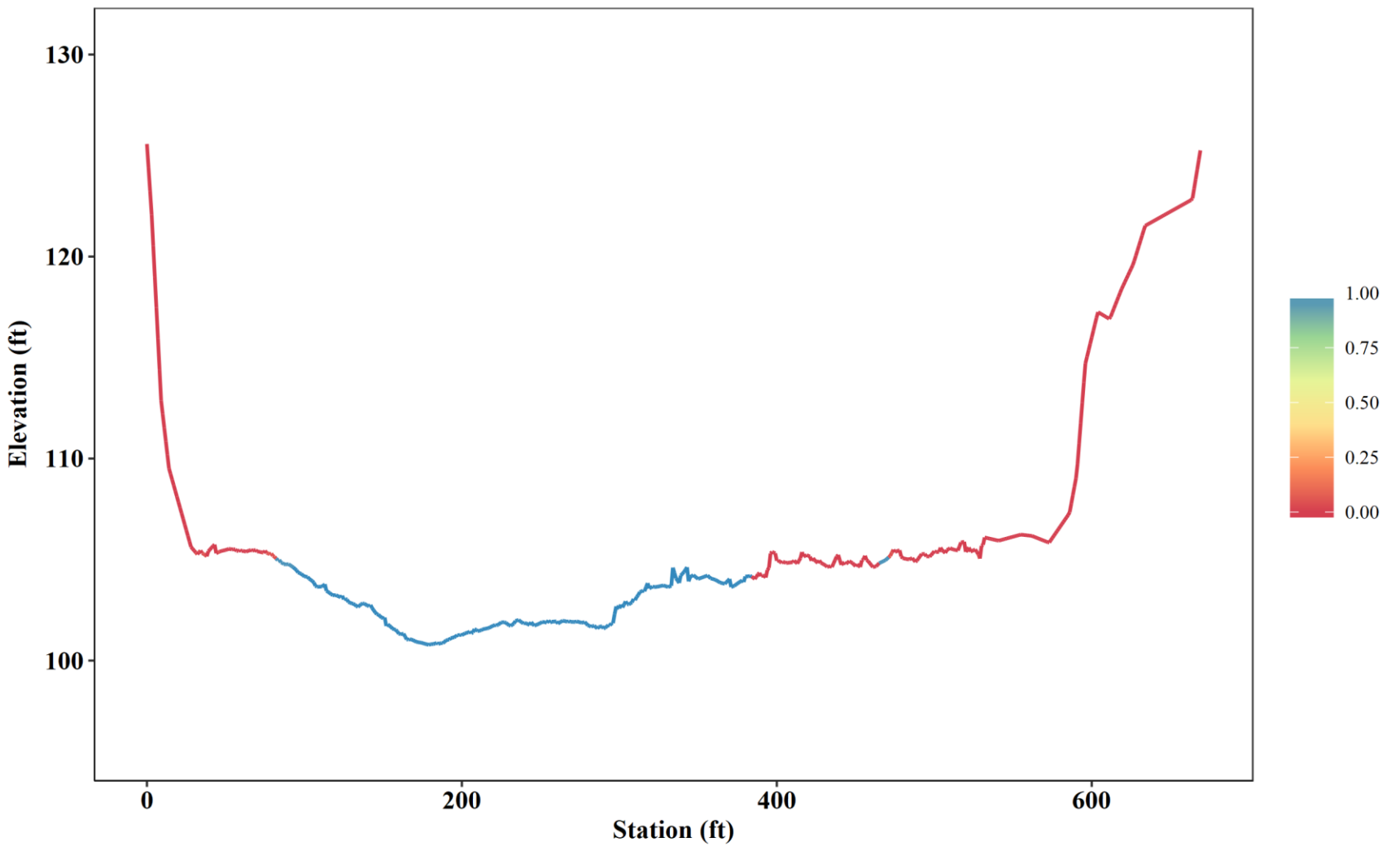

Figure C-20: Persistent Suitable Habitat Available to Proportions of Years for Adult Yellow Lampmussel (1962 through 2003) at T98 during Baseline Operating Conditions.

Note: The colors along the transect profile indicate the proportions of years with persistent habitat available at a given location across the transect.

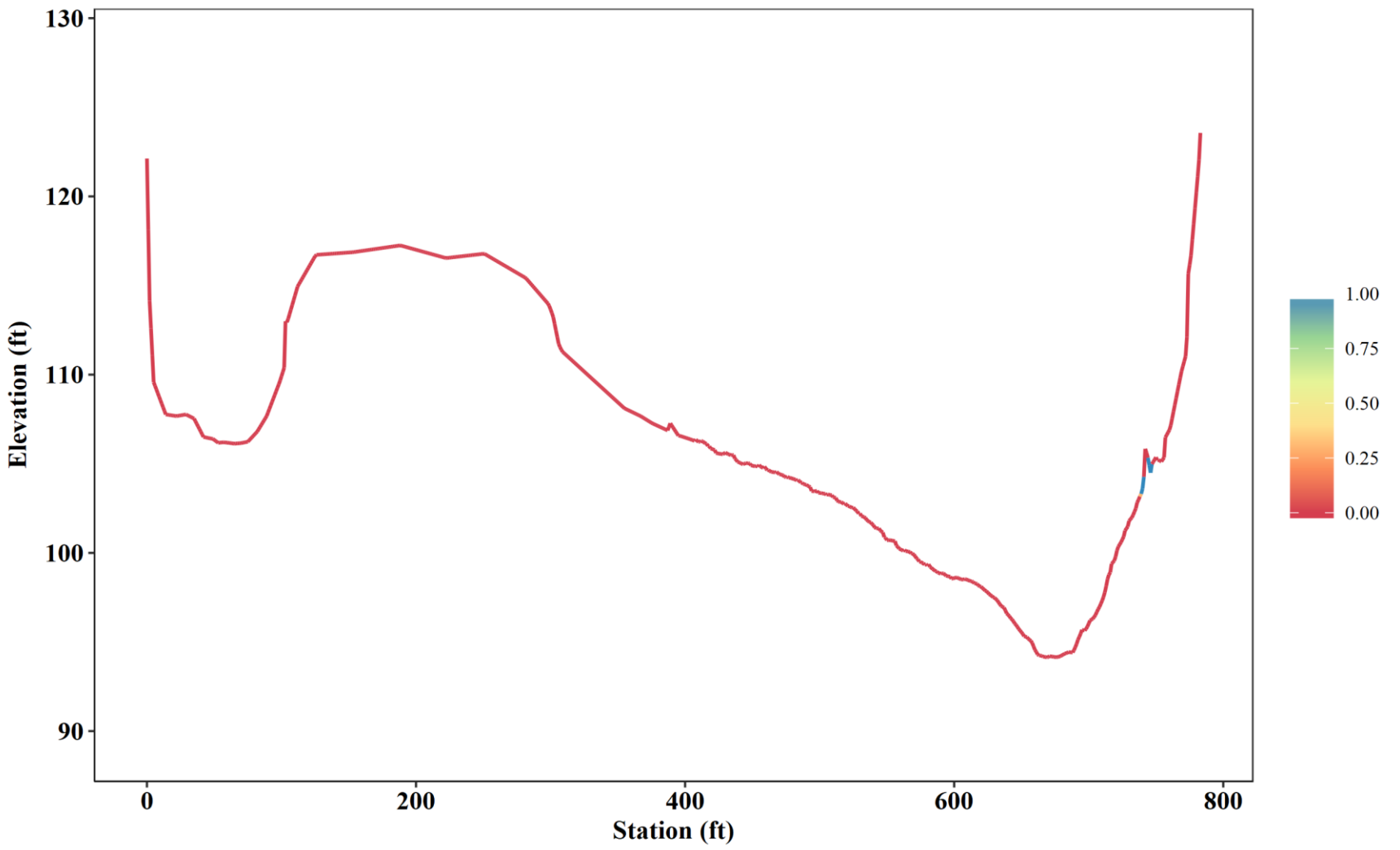

Figure C-21: Persistent Suitable Habitat Available to Proportions of 40 Juvenile Yellow Lampmussel 2-Year Cohorts (1962 through 2003) at T99 during Baseline Operating Conditions.

Note: The colors along the transect profile indicate the proportions of cohorts with persistent habitat available at a given location across the transect.

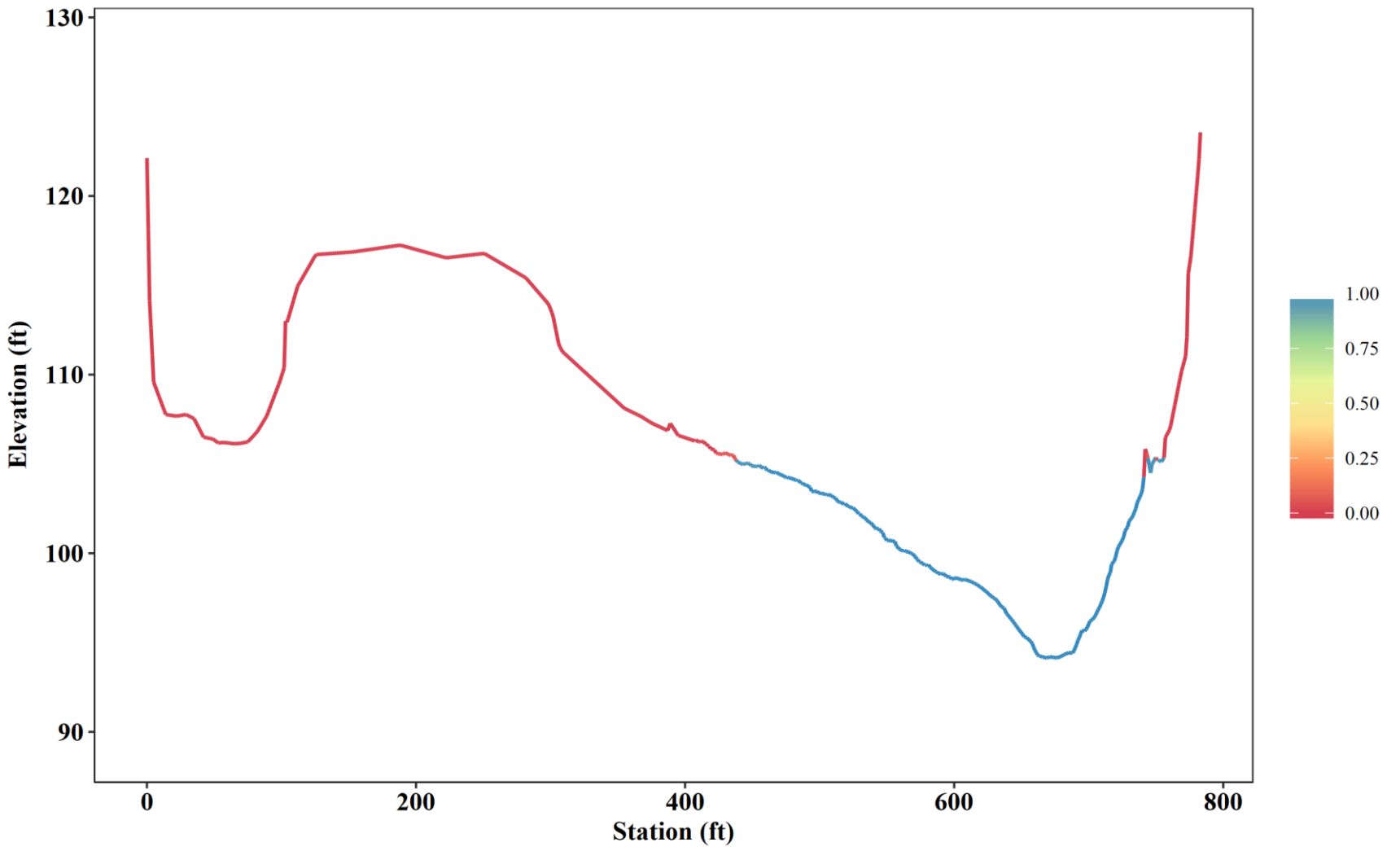

Figure C-22: Persistent Suitable Habitat Available to Proportions of Years for Adult Yellow Lampmussel (1962 through 2003) at T99 during Baseline Operating Conditions.

Note: The colors along the transect profile indicate the proportions of years with persistent habitat available at a given location across the transect.

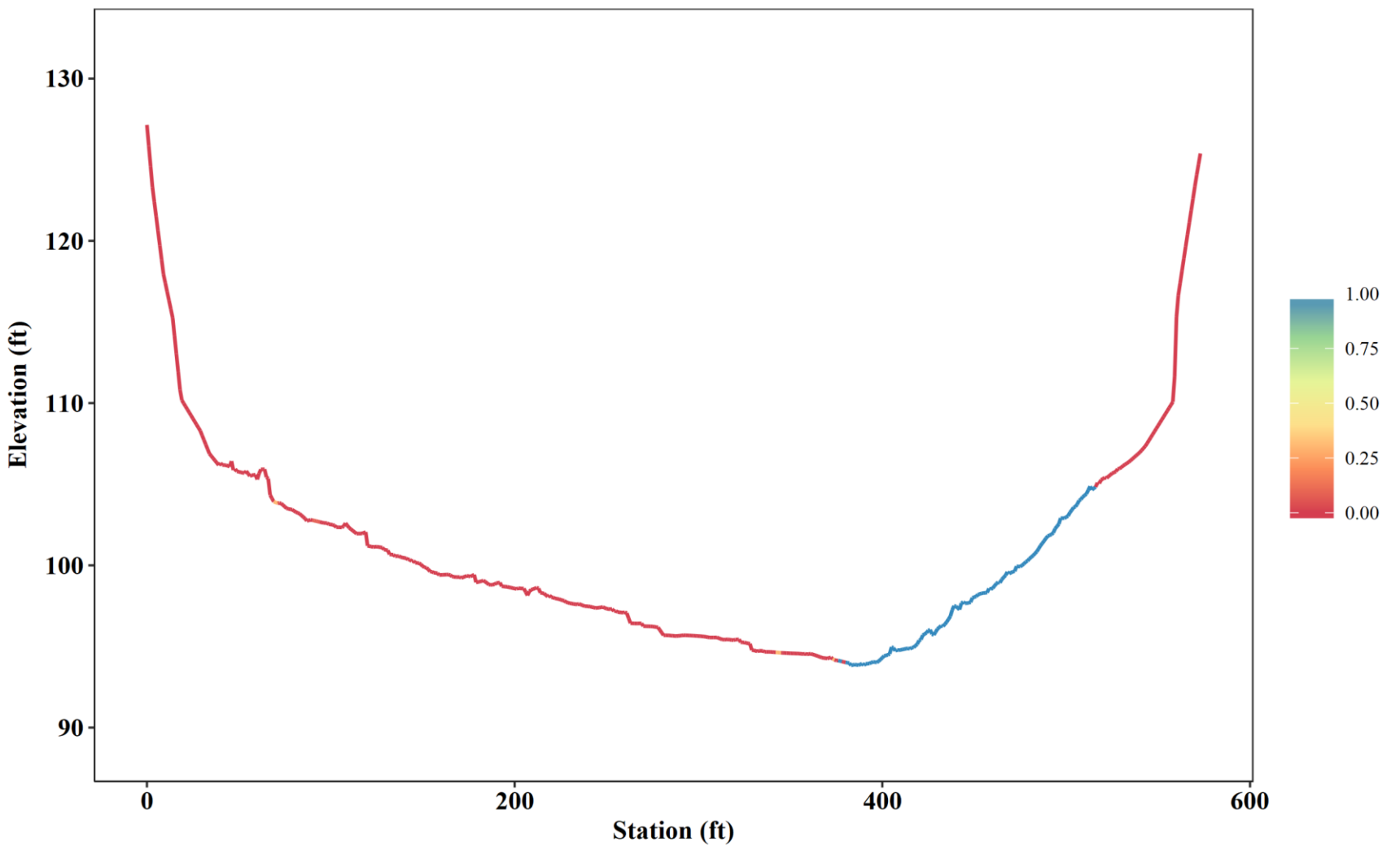

Figure C-23: Persistent Suitable Habitat Available to Proportions of 40 Juvenile Yellow Lampmussel 2-Year Cohorts (1962 through 2003) at T100 during Baseline Operating Conditions.

Note: The colors along the transect profile indicate the proportions of cohorts with persistent habitat available at a given location across the transect.

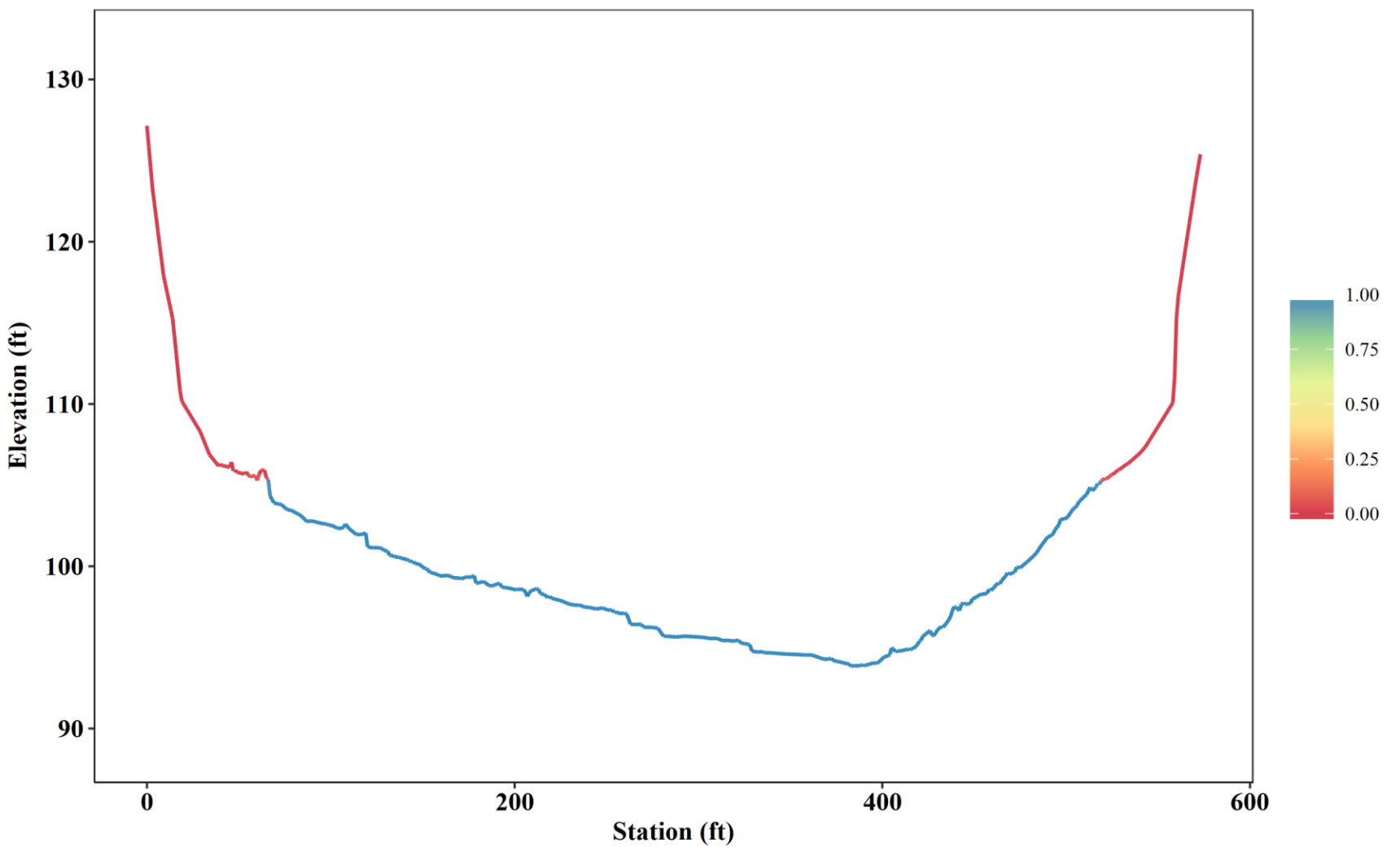

Figure C-24: Persistent Suitable Habitat Available to Proportions of Years for Adult Yellow Lampmussel (1962 through 2003) at T100 during Baseline Operating Conditions.

Note: The colors along the transect profile indicate the proportions of years with persistent habitat available at a given location across the transect.

APPENDIX D: ROR CONDITIONS – YELLOW LAMPMUSSEL PERSISTENT HABITAT TRANSECT PLOTS – JUVENILE AND ADULT COMPARISON

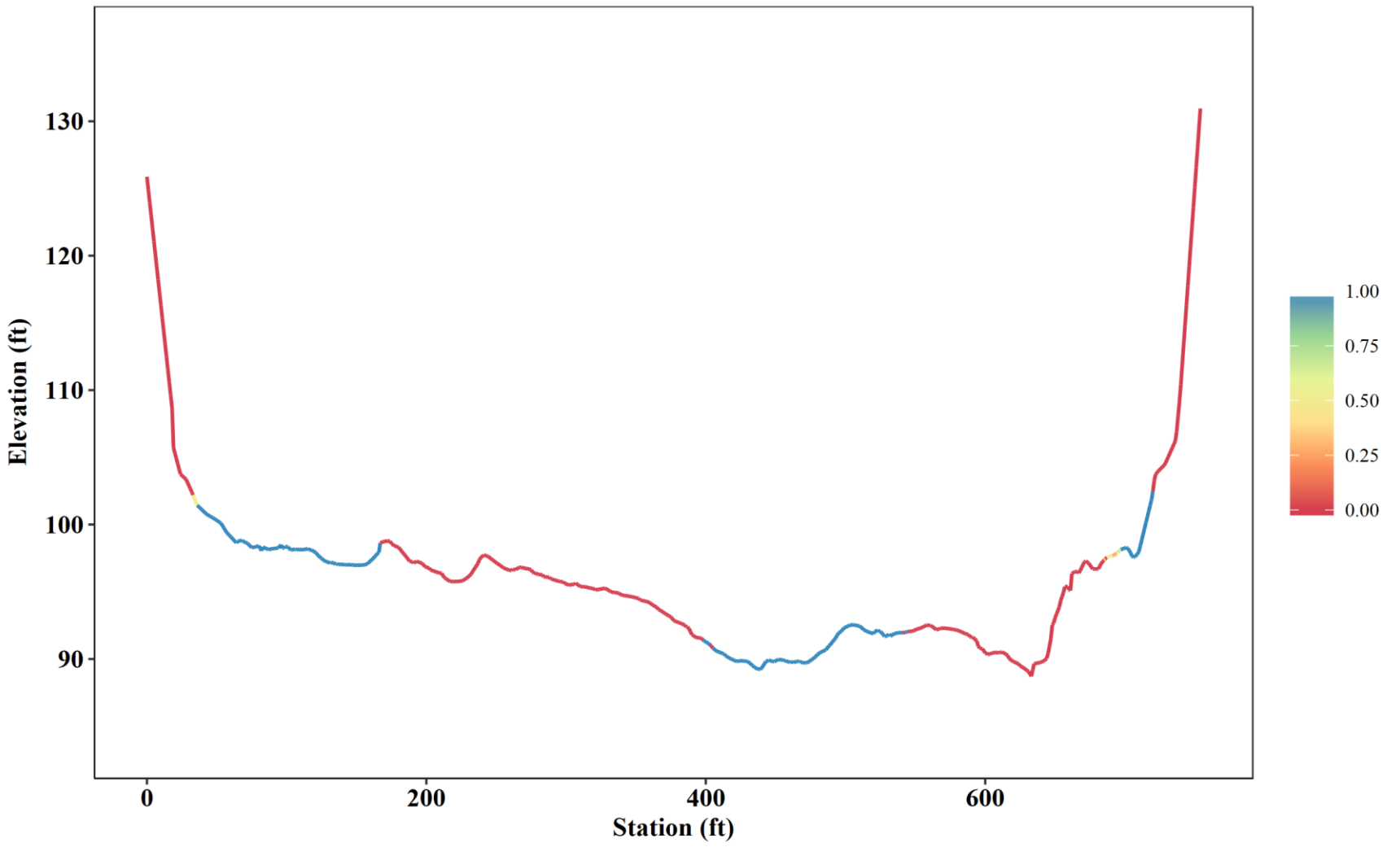

Figure D-1: Persistent Suitable Habitat Available to Proportions of 40 Juvenile Yellow Lampmussel 2-Year Cohorts (1962 through 2003) at T87 during ROR Operating Conditions.

Note: The colors along the transect profile indicate the proportions of cohorts with persistent habitat available at a given location across the transect.

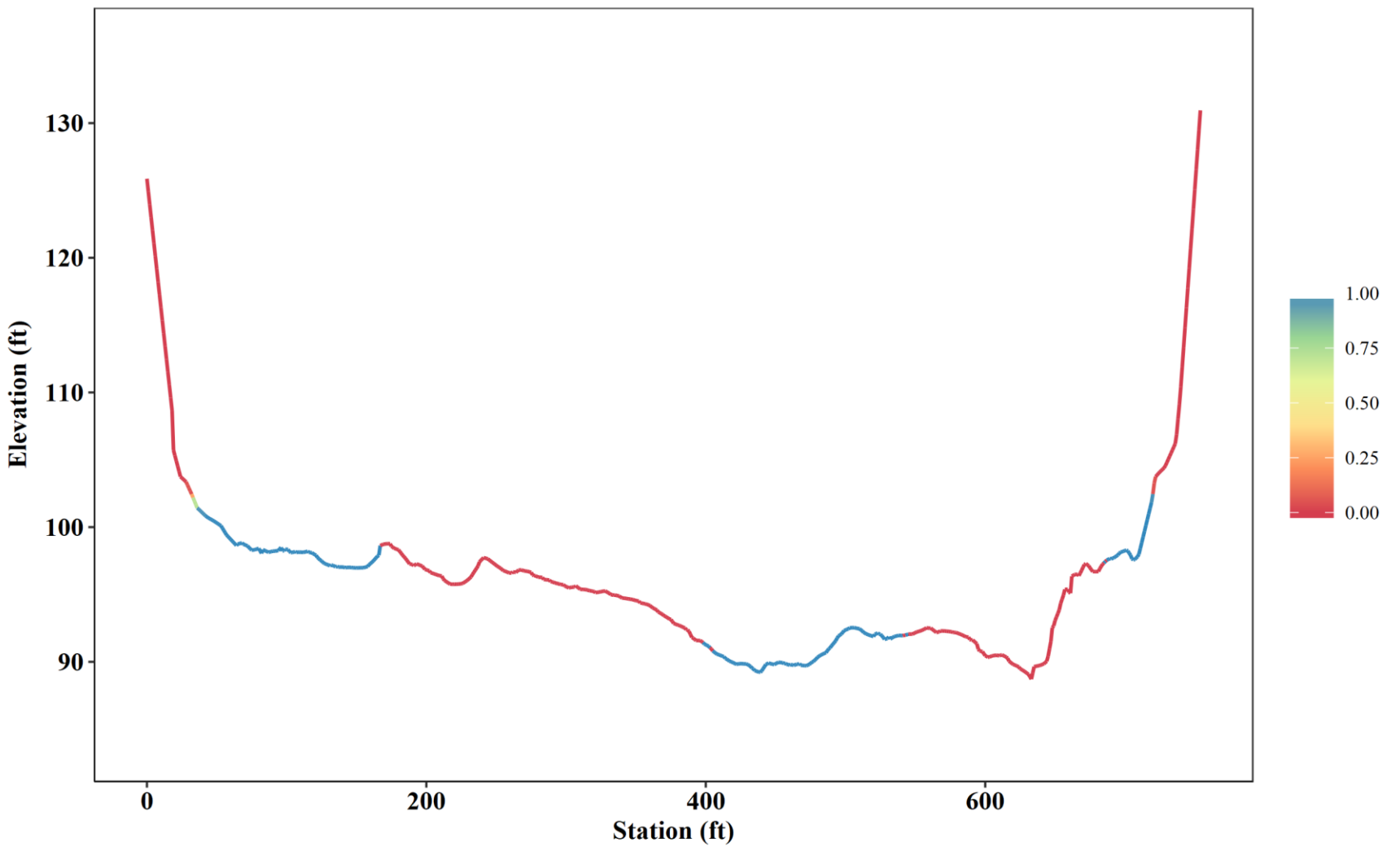

Figure D-2: Persistent Suitable Habitat Available to Proportions of Years for Adult Yellow Lampmussel (1962 through 2003) at T87 during ROR Operating Conditions.

Note: The colors along the transect profile indicate the proportions of years with persistent habitat available at a given location across the transect.

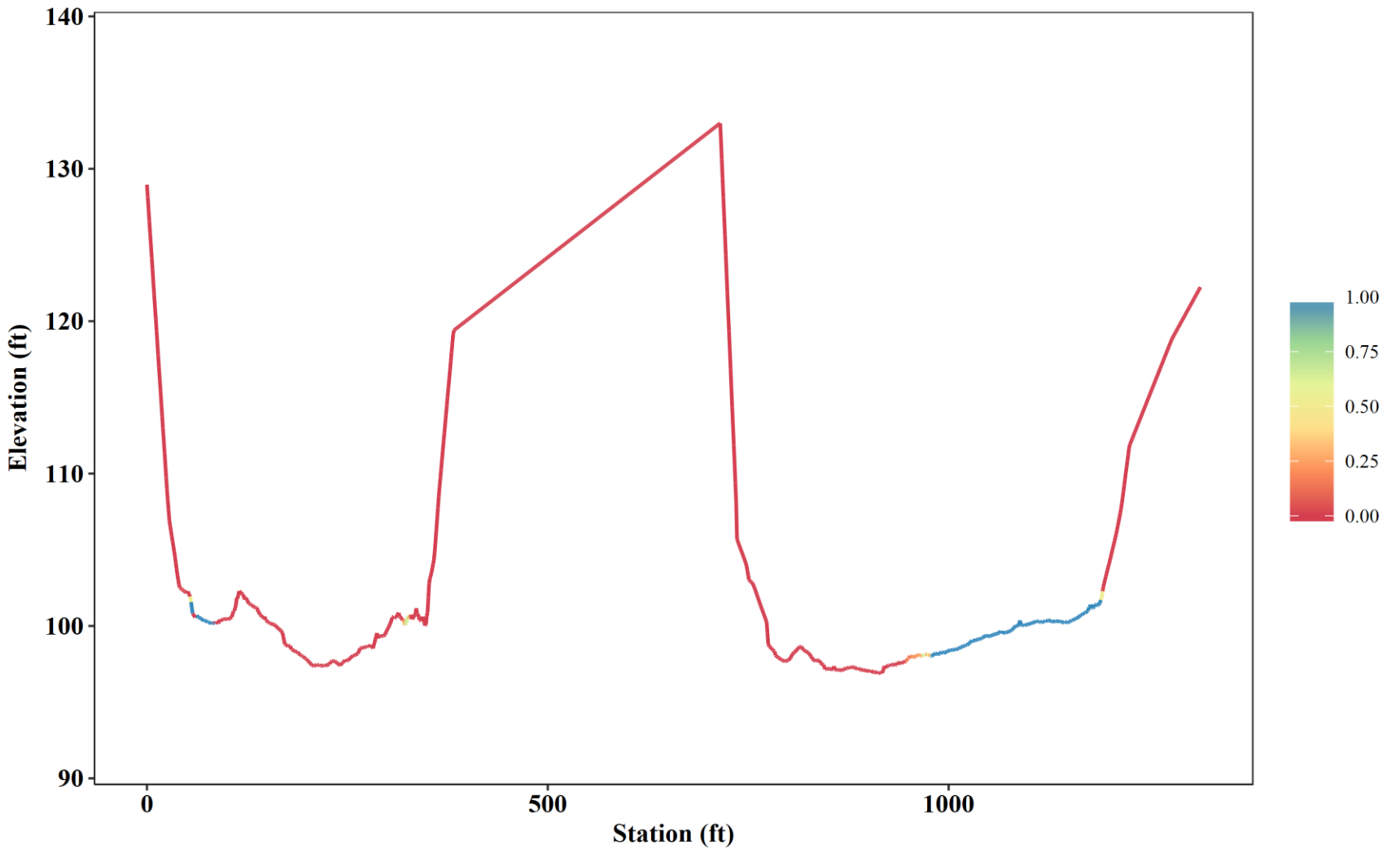

Figure D-3: Persistent Suitable Habitat Available to Proportions of 40 Juvenile Yellow Lampmussel 2-Year Cohorts (1962 through 2003) at T88 during ROR Operating Conditions.

Note: The colors along the transect profile indicate the proportions of cohorts with persistent habitat available at a given location across the transect.

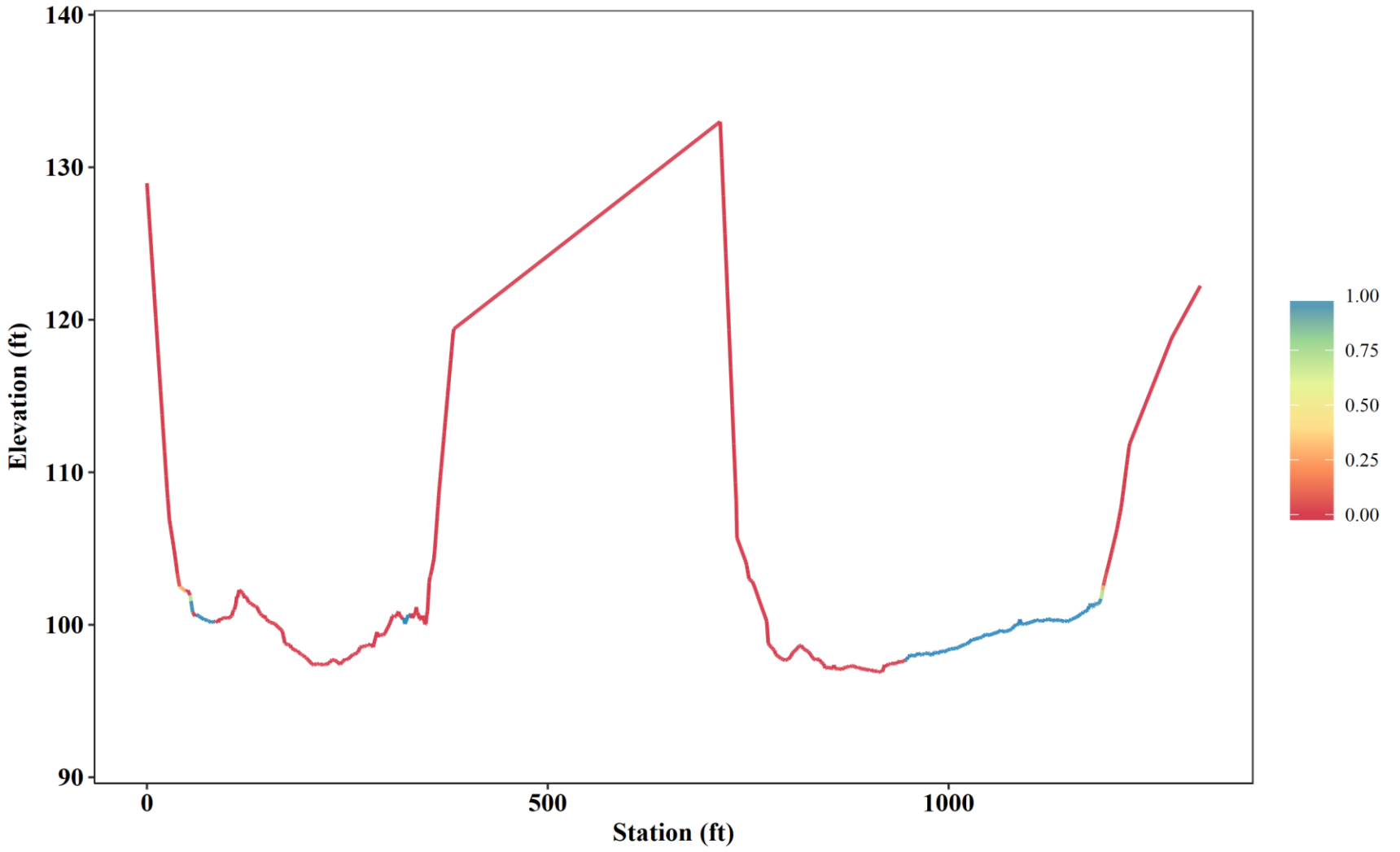

Figure D-4: Persistent Suitable Habitat Available to Proportions of Years for Adult Yellow Lampmussel (1962 through 2003) at T88 during ROR Operating Conditions.

Note: The colors along the transect profile indicate the proportions of years with persistent habitat available at a given location across the transect.

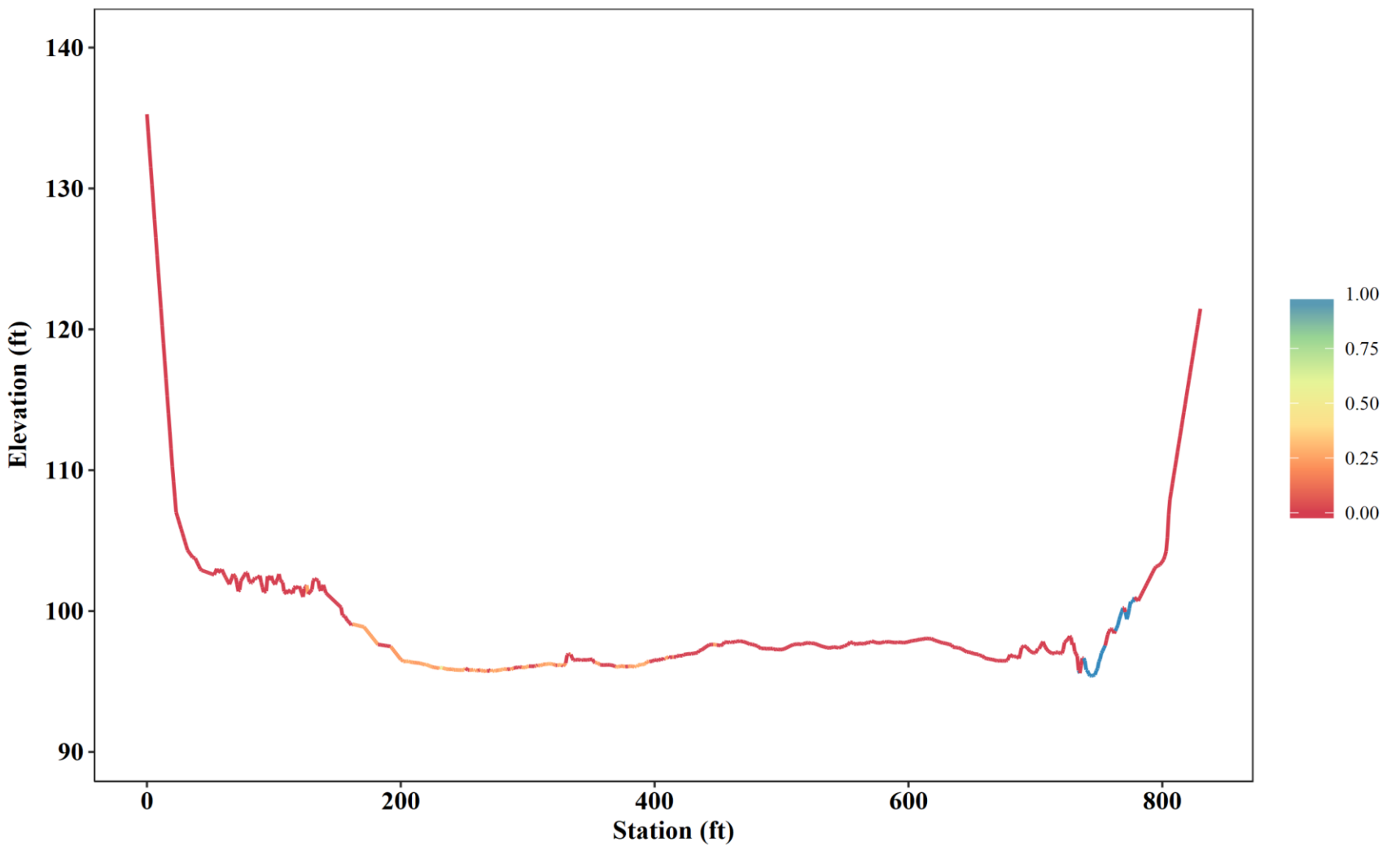

Figure D-5: Persistent Suitable Habitat Available to Proportions of 40 Juvenile Yellow Lampmussel 2-Year Cohorts (1962 through 2003) at T89 during ROR Operating Conditions.

Note: The colors along the transect profile indicate the proportions of cohorts with persistent habitat available at a given location across the transect.

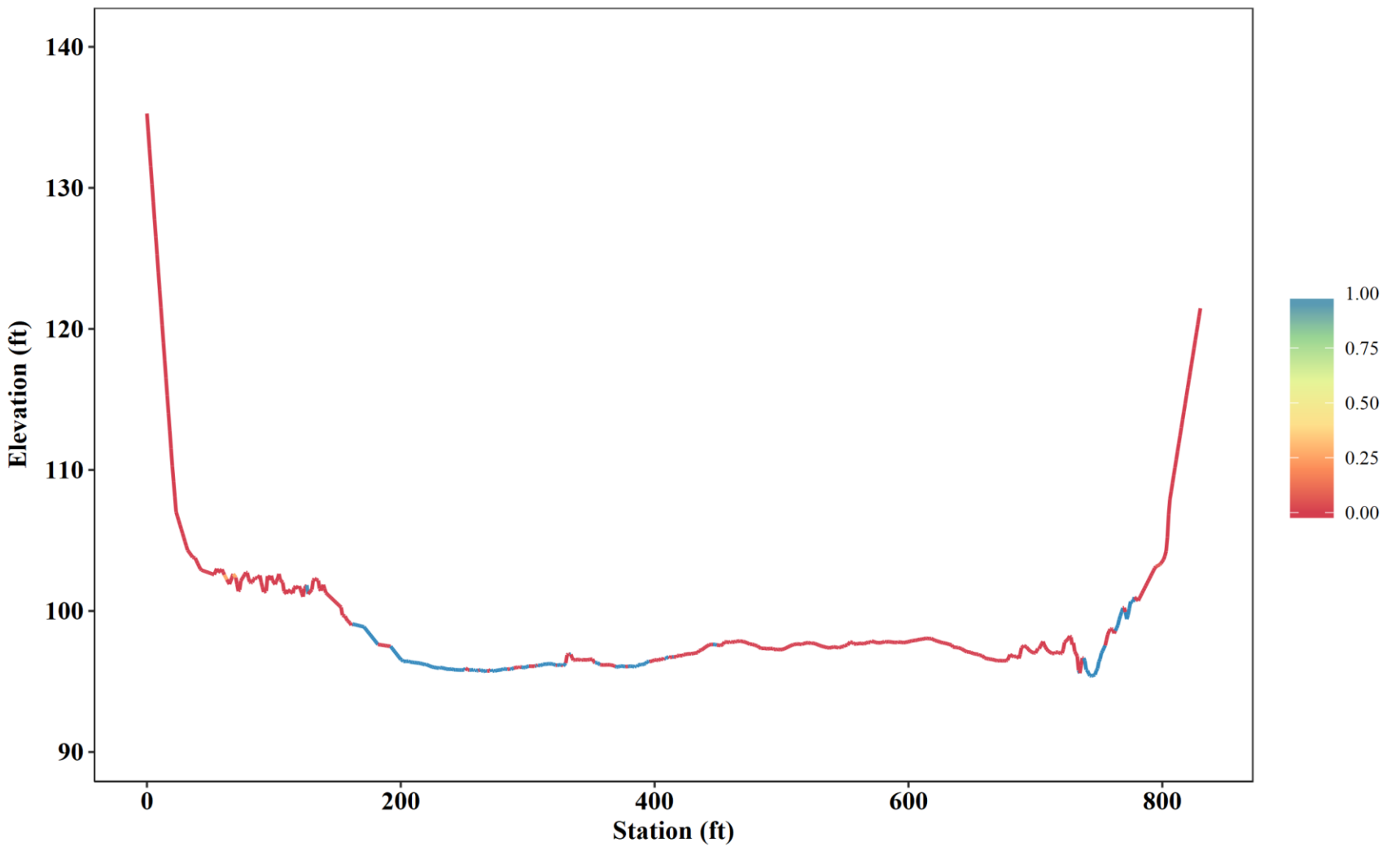

Figure D-6: Persistent Suitable Habitat Available to Proportions of Years for Adult Yellow Lampmussel (1962 through 2003) at T89 during ROR Operating Conditions.

Note: The colors along the transect profile indicate the proportions of years with persistent habitat available at a given location across the transect

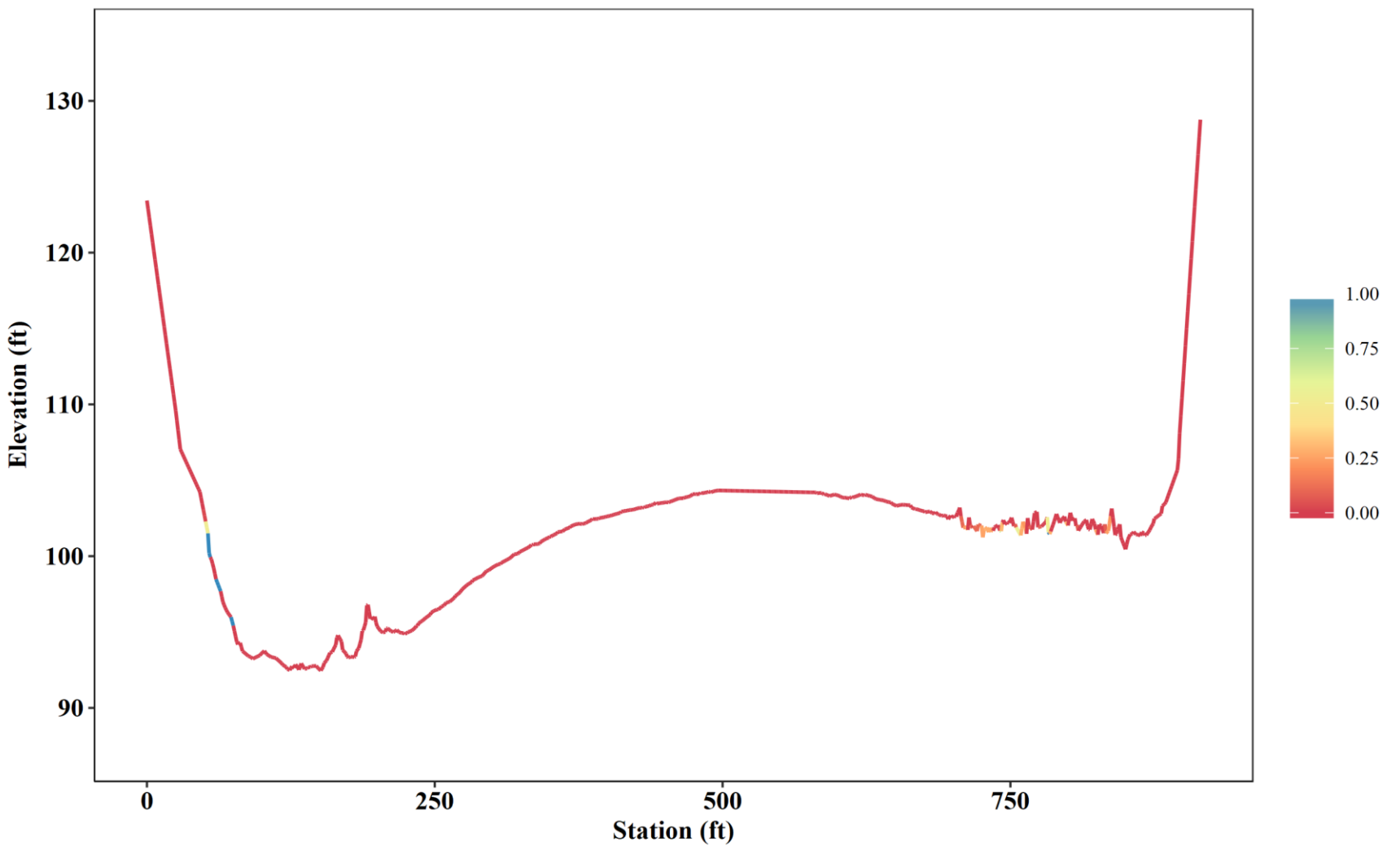

Figure D-7: Persistent Suitable Habitat Available to Proportions of 40 Juvenile Yellow Lampmussel 2-Year Cohorts (1962 through 2003) at T90 during ROR Operating Conditions.

Note: The colors along the transect profile indicate the proportions of cohorts with persistent habitat available at a given location across the transect.

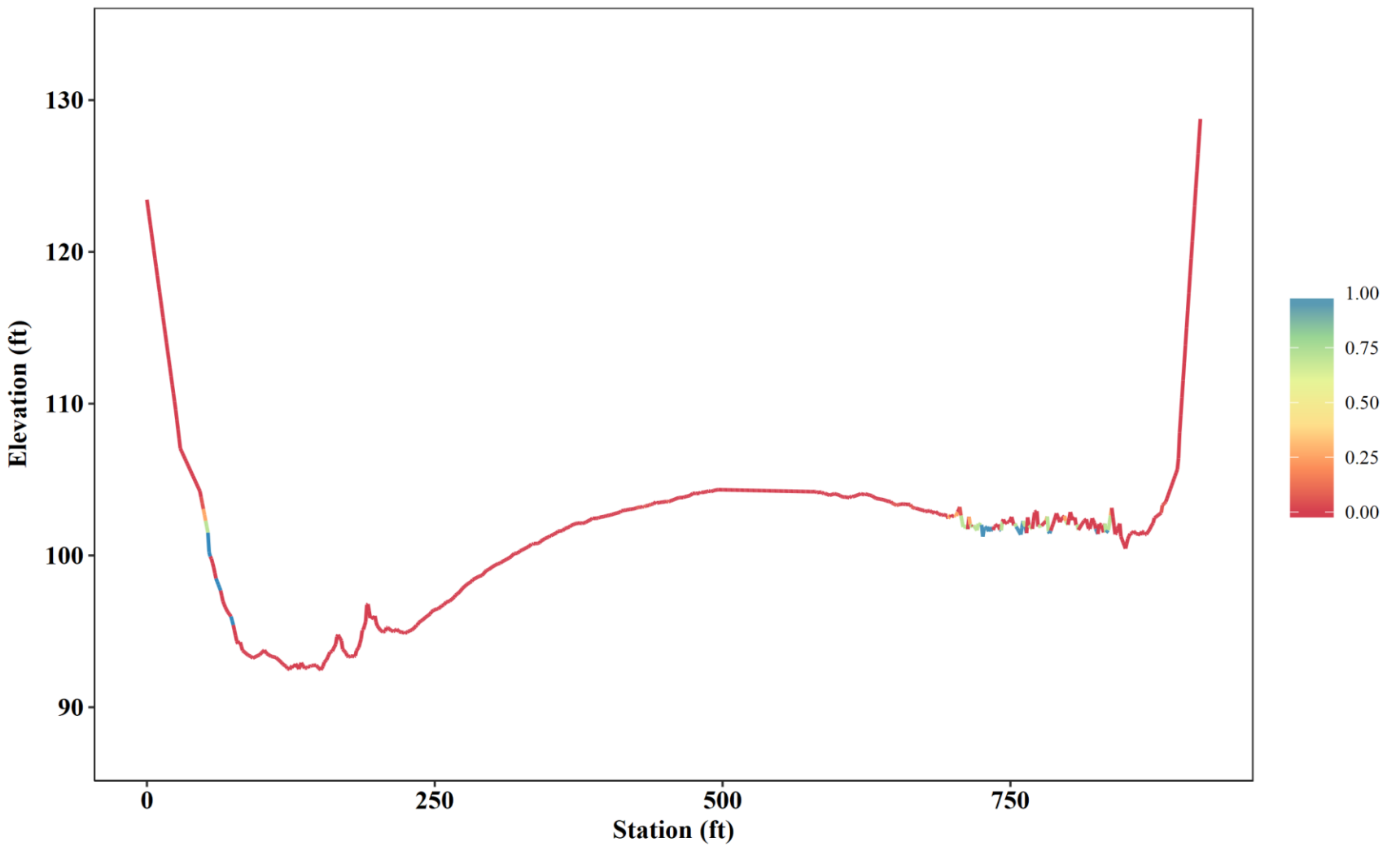

Figure D-8: Persistent Suitable Habitat Available to Proportions of Years for Adult Yellow Lampmussel (1962 through 2003) at T90 during ROR Operating Conditions.

Note: The colors along the transect profile indicate the proportions of years with persistent habitat available at a given location across the transect.

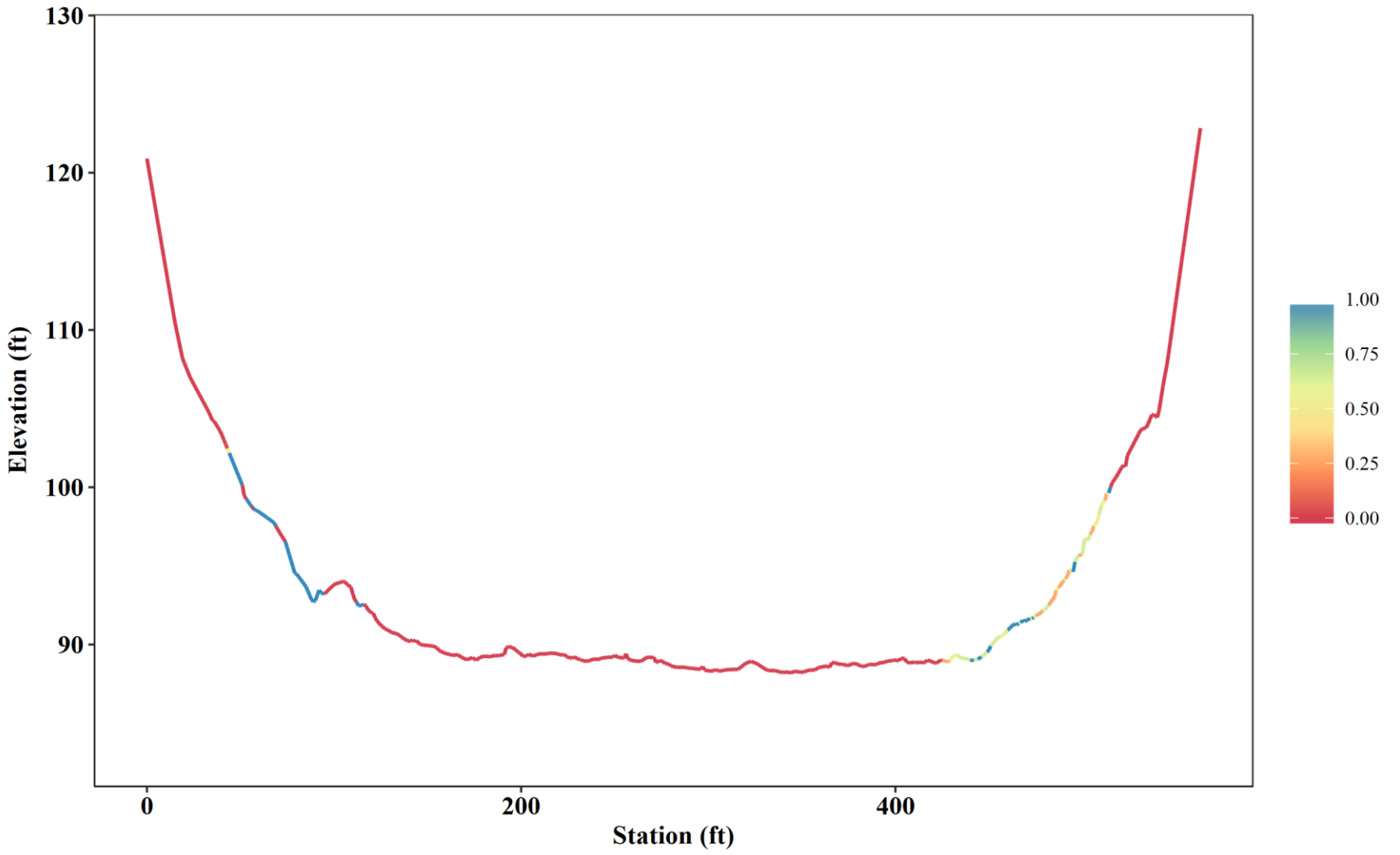

Figure D-9: Persistent Suitable Habitat Available to Proportions of 40 Juvenile Yellow Lampmussel 2-Year Cohorts (1962 through 2003) at T91 during ROR Operating Conditions.

Note: The colors along the transect profile indicate the proportions of cohorts with persistent habitat available at a given location across the transect.

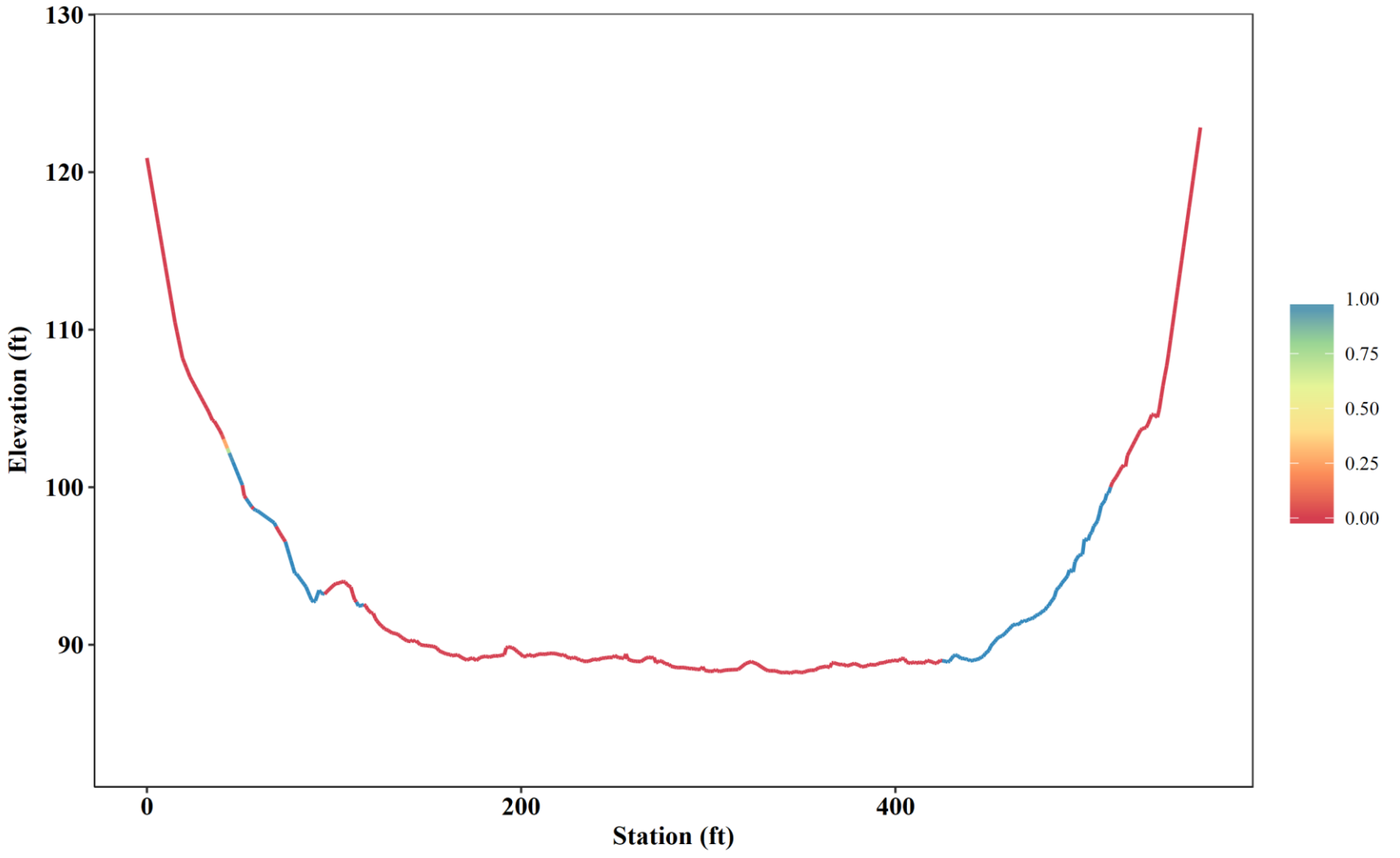

Figure D-10: Persistent Suitable Habitat Available to Proportions of Years for Adult Yellow Lampmussel (1962 through 2003) at T91 during ROR Operating Conditions.

Note: The colors along the transect profile indicate the proportions of years with persistent habitat available at a given location across the transect.

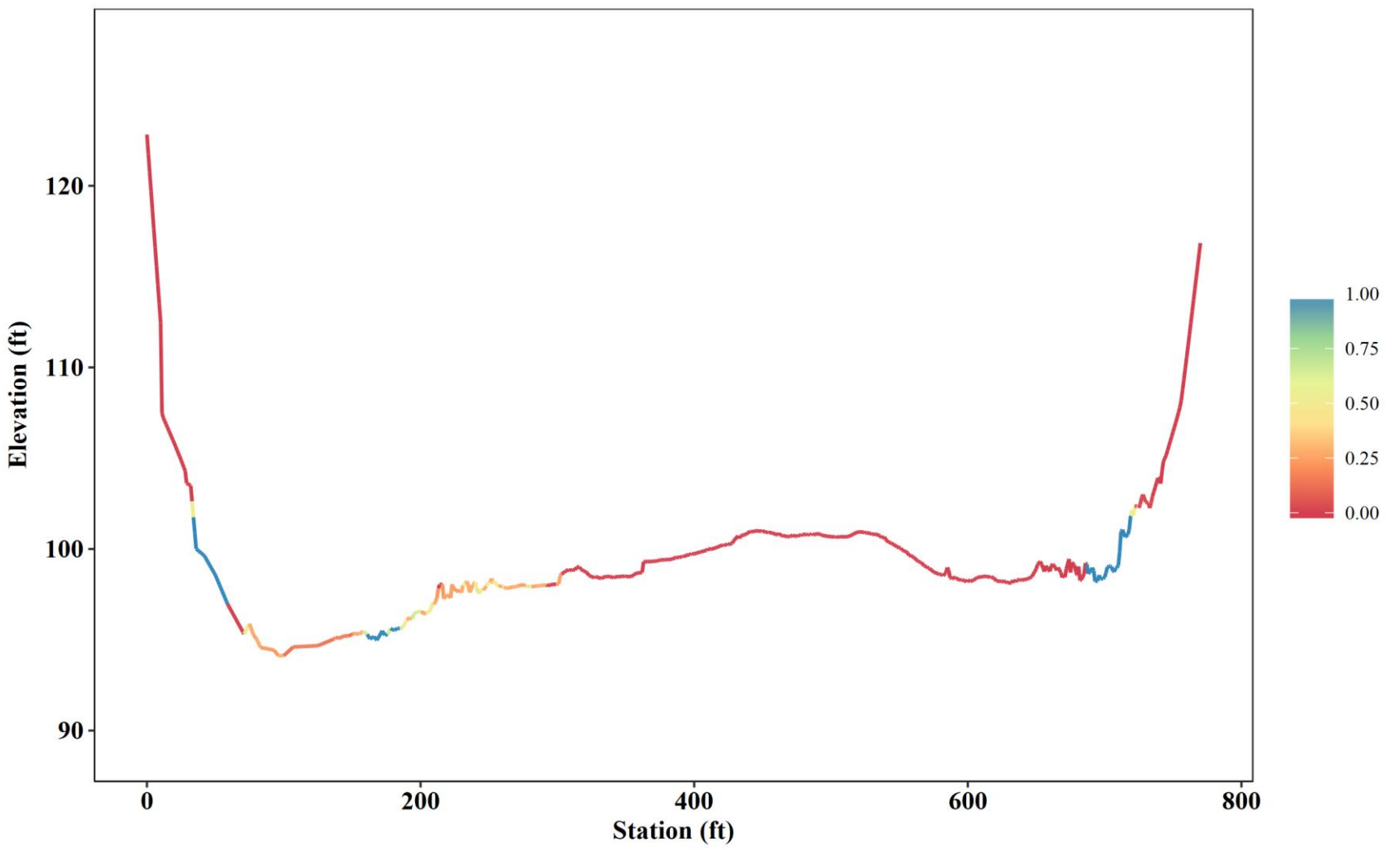

Figure D-11: Persistent Suitable Habitat Available to Proportions of 40 Juvenile Yellow Lampmussel 2-Year Cohorts (1962 through 2003) at T92 during ROR Operating Conditions.

Note: The colors along the transect profile indicate the proportions of cohorts with persistent habitat available at a given location across the transect.

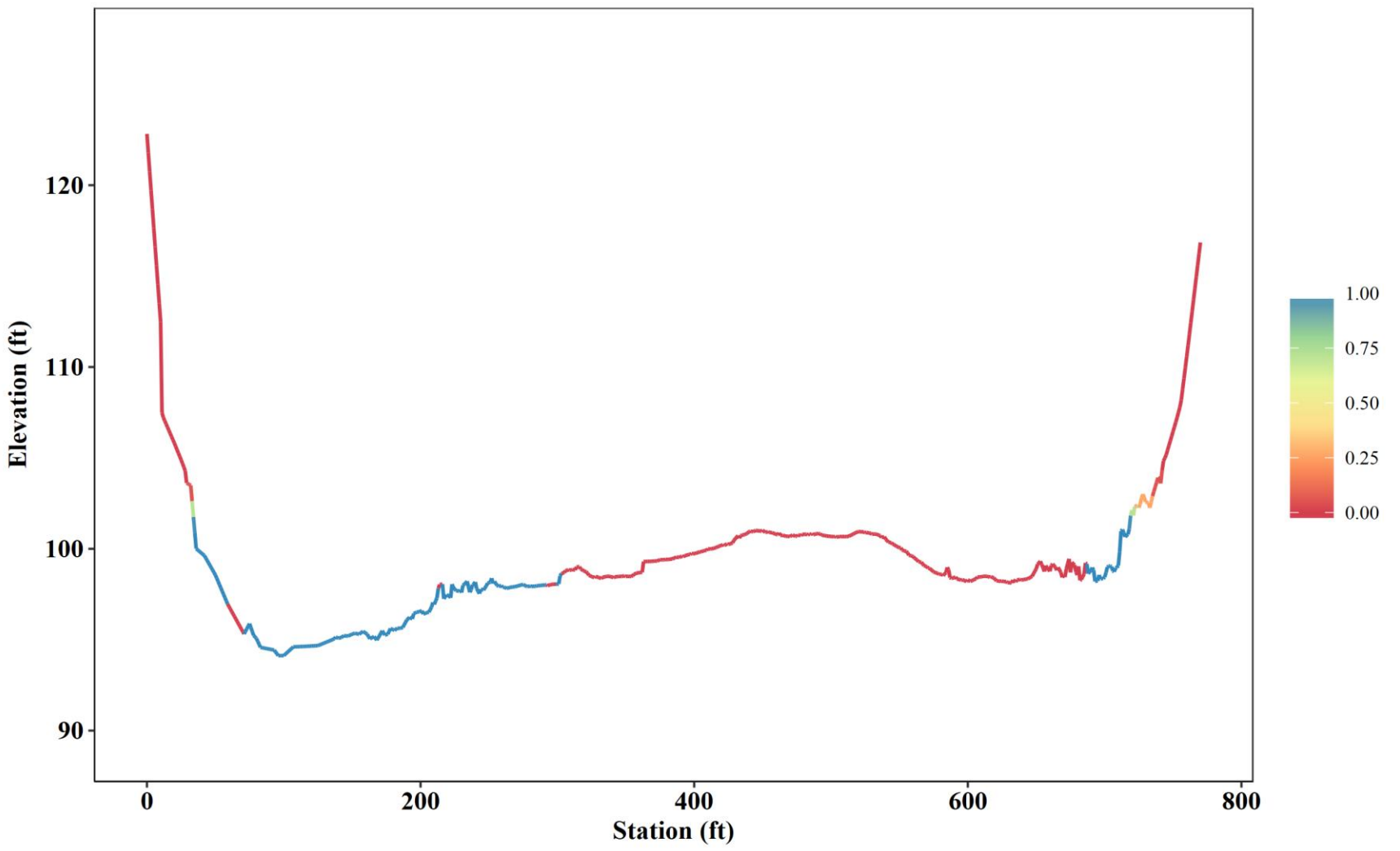

Figure D-12: Persistent Suitable Habitat Available to Proportions of Years for Adult Yellow Lampmussel (1962 through 2003) at T92 during ROR Operating Conditions.

Note: The colors along the transect profile indicate the proportions of years with persistent habitat available at a given location across the transect.

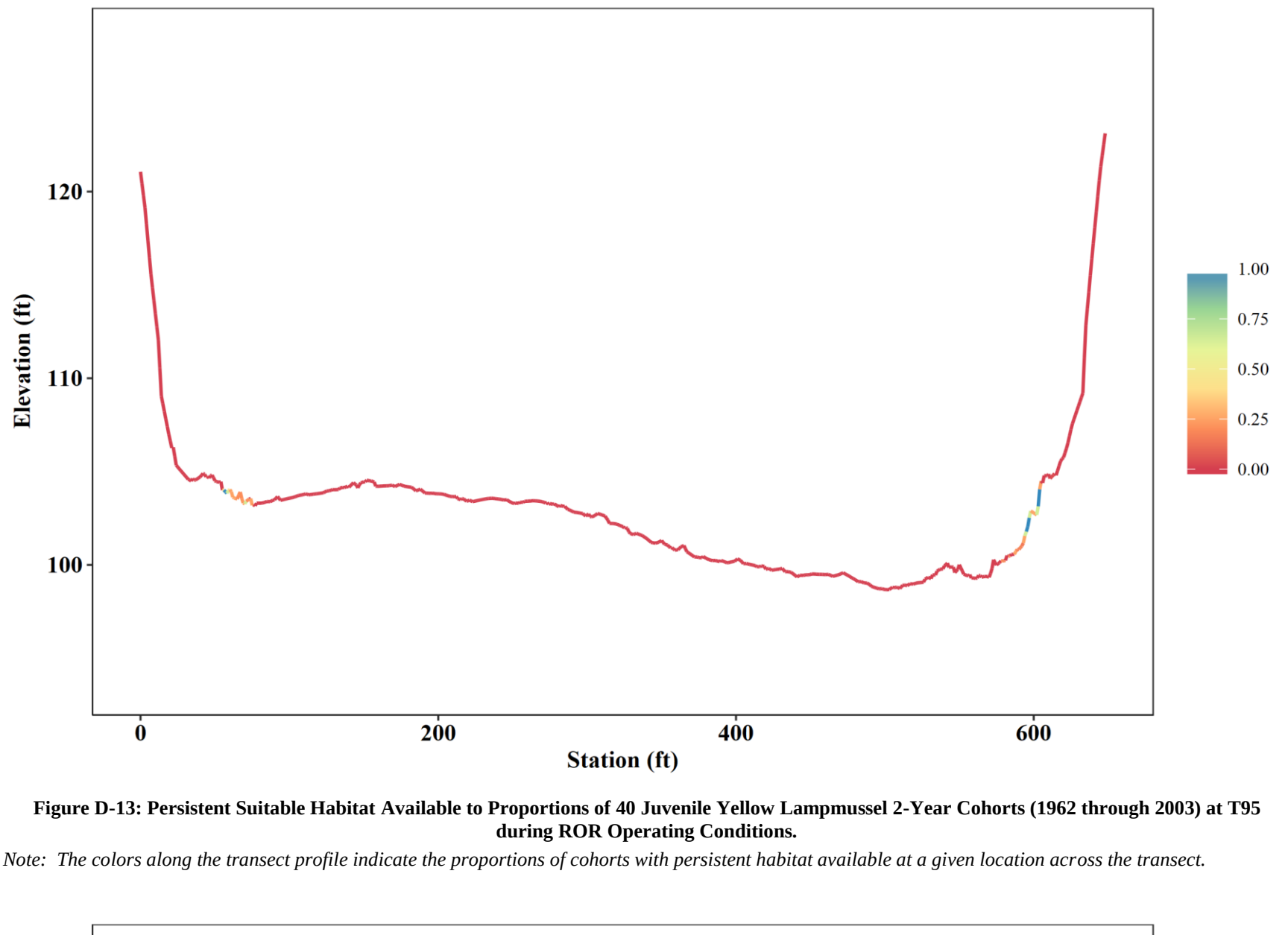

Figure D-13: Persistent Suitable Habitat Available to Proportions of 40 Juvenile Yellow Lampmussel 2-Year Cohorts (1962 through 2003) at T95 during ROR Operating Conditions.

Note: The colors along the transect profile indicate the proportions of cohorts with persistent habitat available at a given location across the transect.

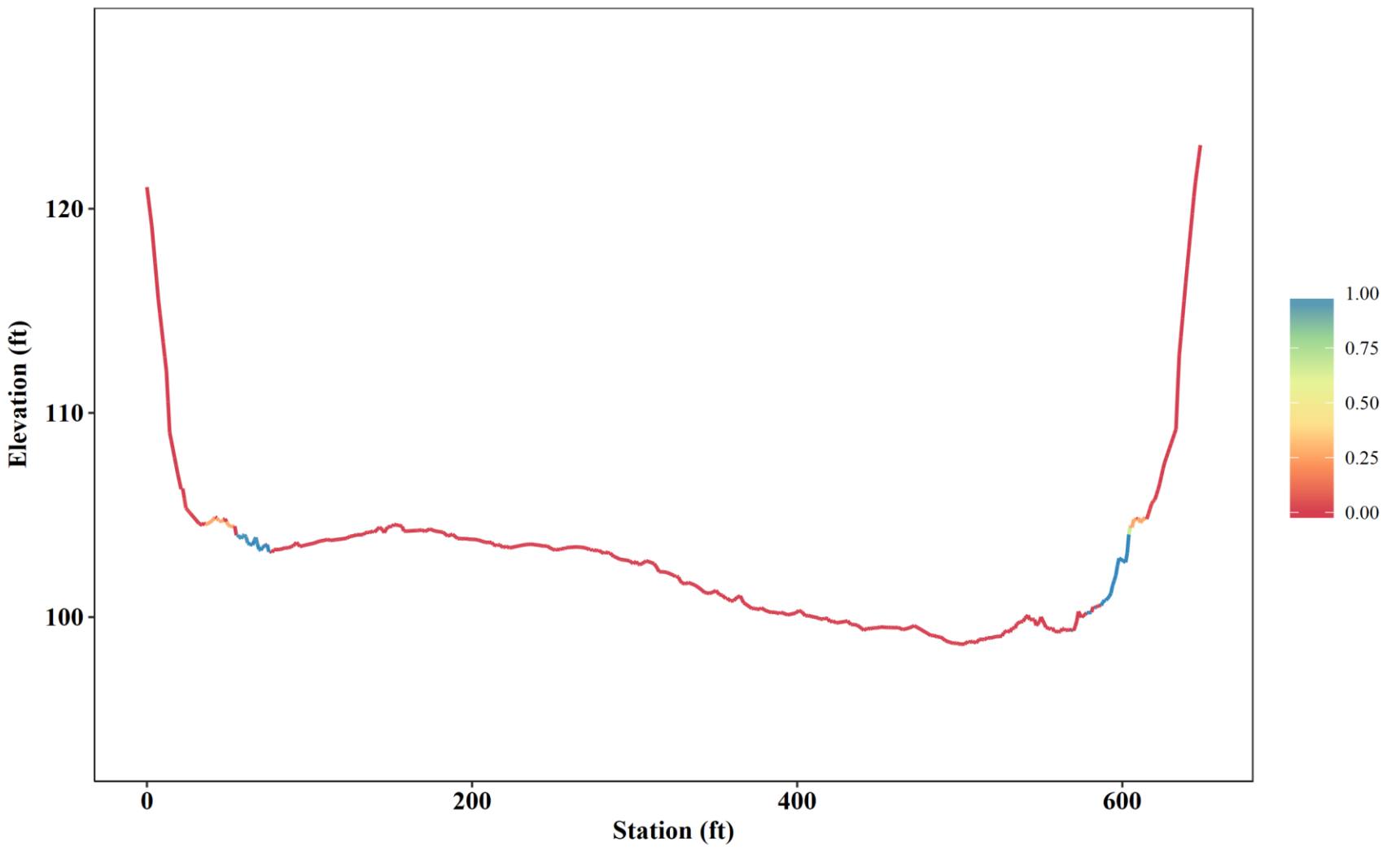

Figure D-14: Persistent Suitable Habitat Available to Proportions of Years for Adult Yellow Lampmussel (1962 through 2003) at T95 during ROR Operating Conditions.

Note: The colors along the transect profile indicate the proportions of years with persistent habitat available at a given location across the transect.

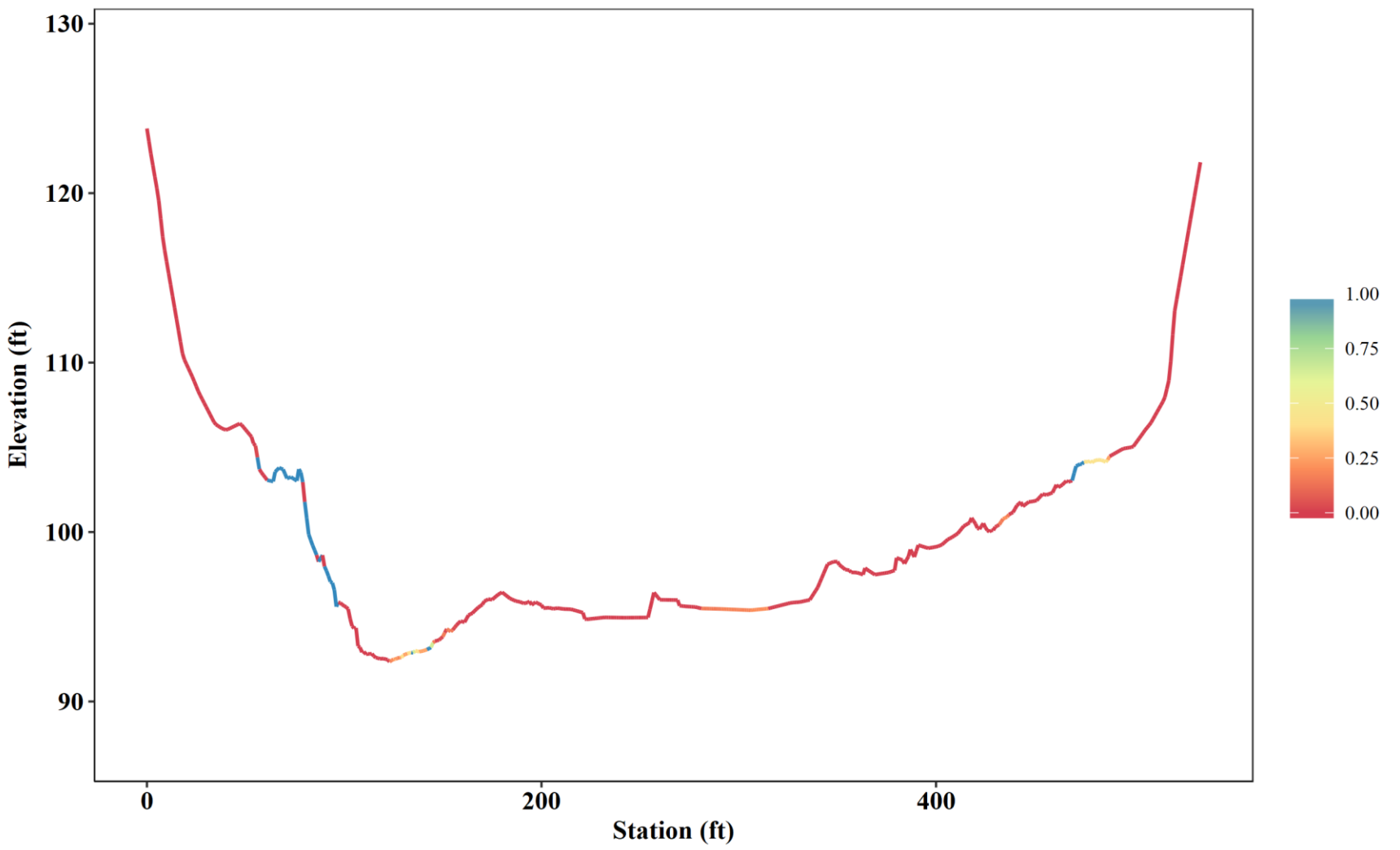

Figure D-15: Persistent Suitable Habitat Available to Proportions of 40 Juvenile Yellow Lampmussel 2-Year Cohorts (1962 through 2003) at T96 during ROR Operating Conditions.

Note: The colors along the transect profile indicate the proportions of cohorts with persistent habitat available at a given location across the transect.

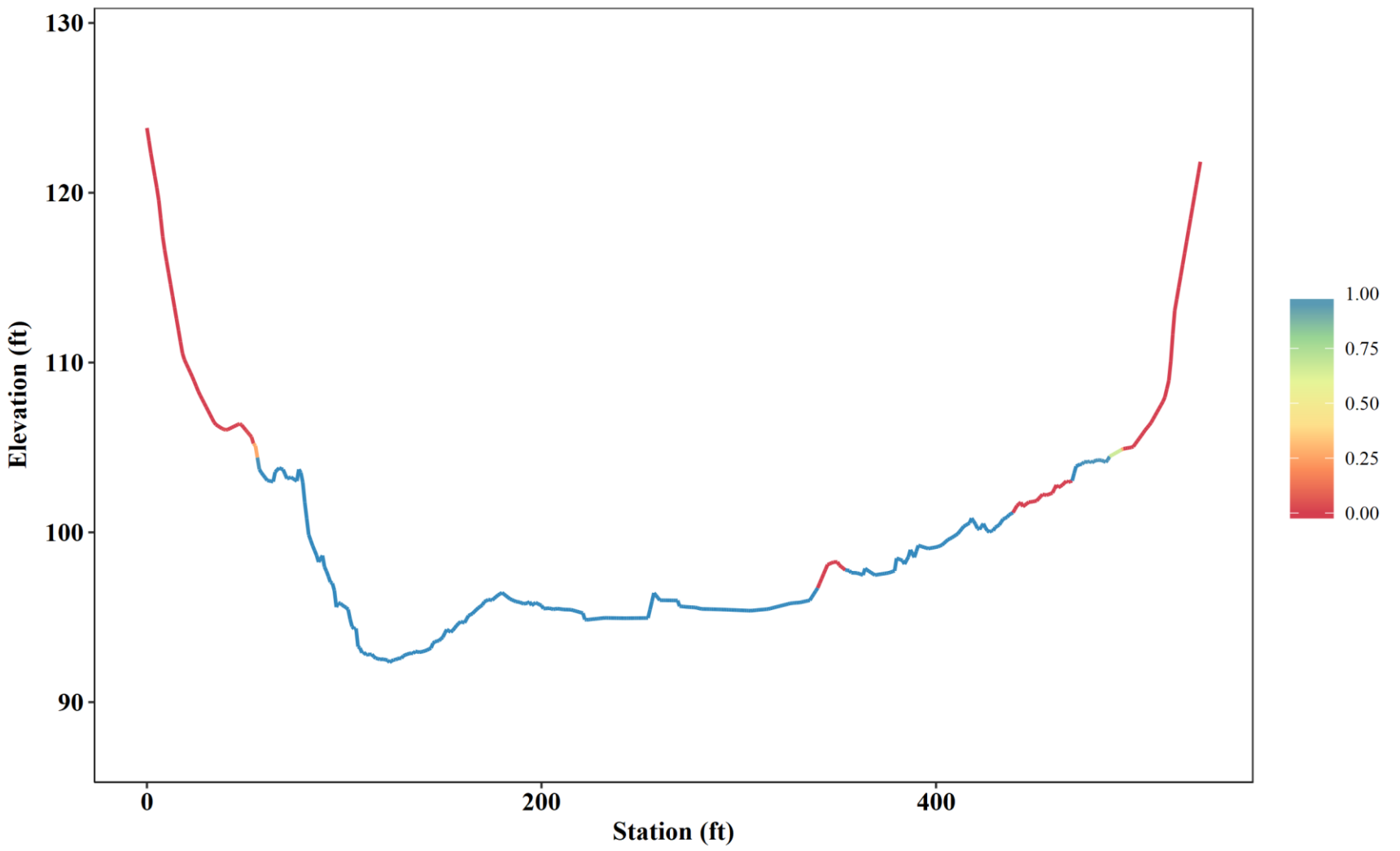

Figure D-16: Persistent Suitable Habitat Available to Proportions of Years for Adult Yellow Lampmussel (1962 through 2003) at T96 during ROR Operating Conditions.

Note: The colors along the transect profile indicate the proportions of years with persistent habitat available at a given location across the transect.

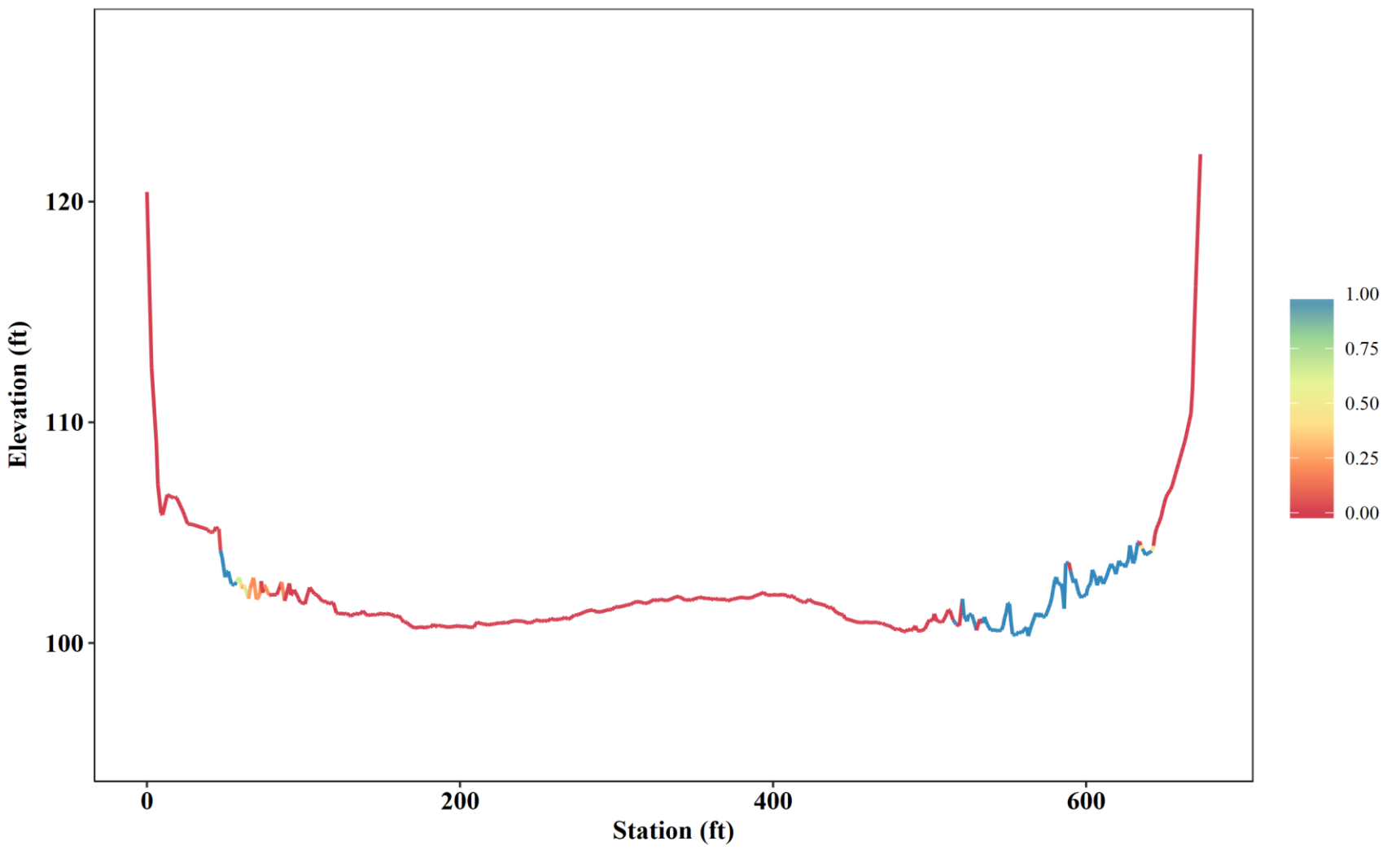

Figure D-17: Persistent Suitable Habitat Available to Proportions of 40 Juvenile Yellow Lampmussel 2-Year Cohorts (1962 through 2003) at T97 during ROR Operating Conditions.

Note: The colors along the transect profile indicate the proportions of cohorts with persistent habitat available at a given location across the transect.

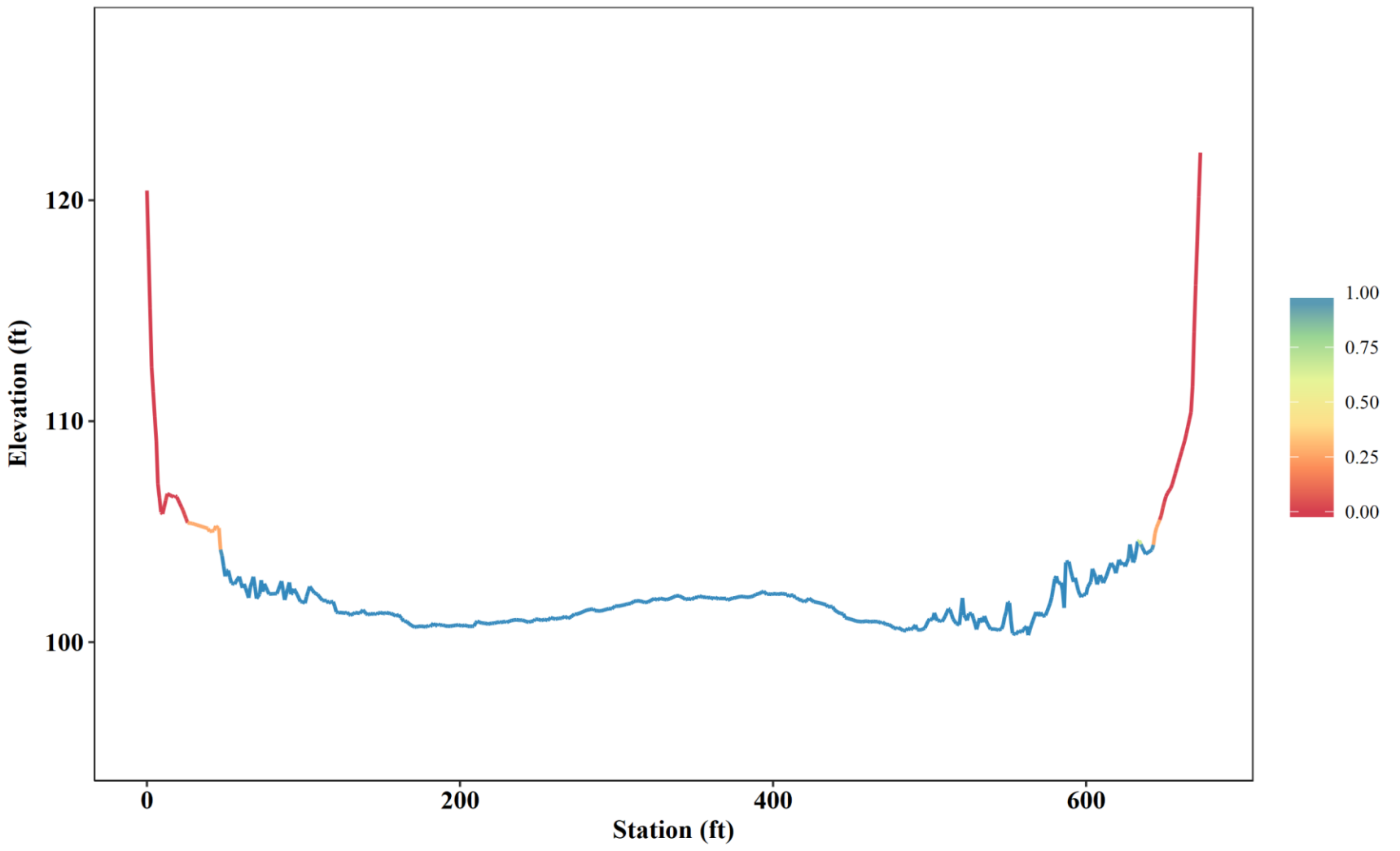

Figure D-18: Persistent Suitable Habitat Available to Proportions of Years for Adult Yellow Lampmussel (1962 through 2003) at T97 during ROR Operating Conditions.

Note: The colors along the transect profile indicate the proportions of years with persistent habitat available at a given location across the transect.

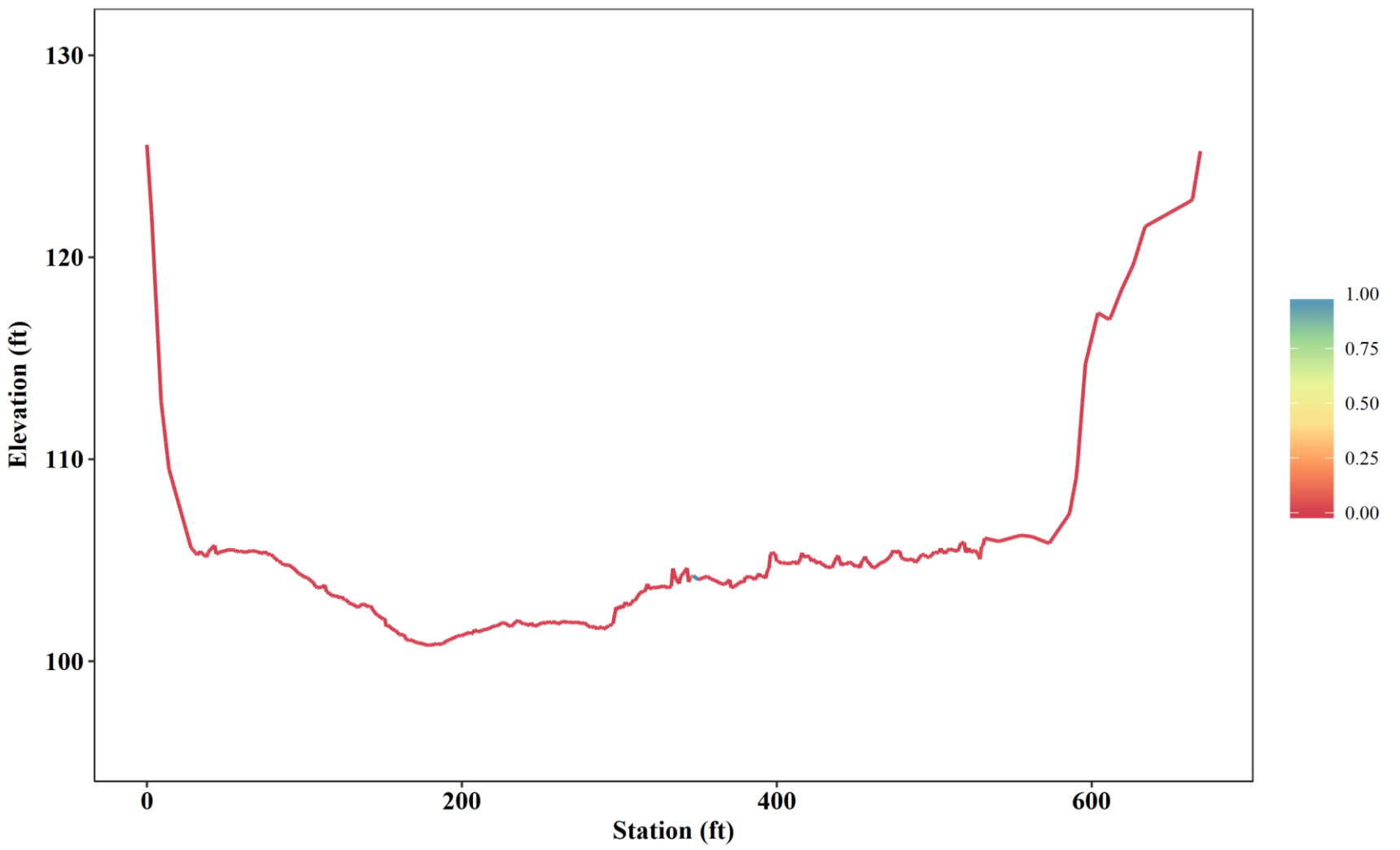

Figure D-19: Persistent Suitable Habitat Available to Proportions of 40 Juvenile Yellow Lampmussel 2-Year Cohorts (1962 through 2003) at T98 during ROR Operating Conditions.

Note: The colors along the transect profile indicate the proportions of cohorts with persistent habitat available at a given location across the transect.

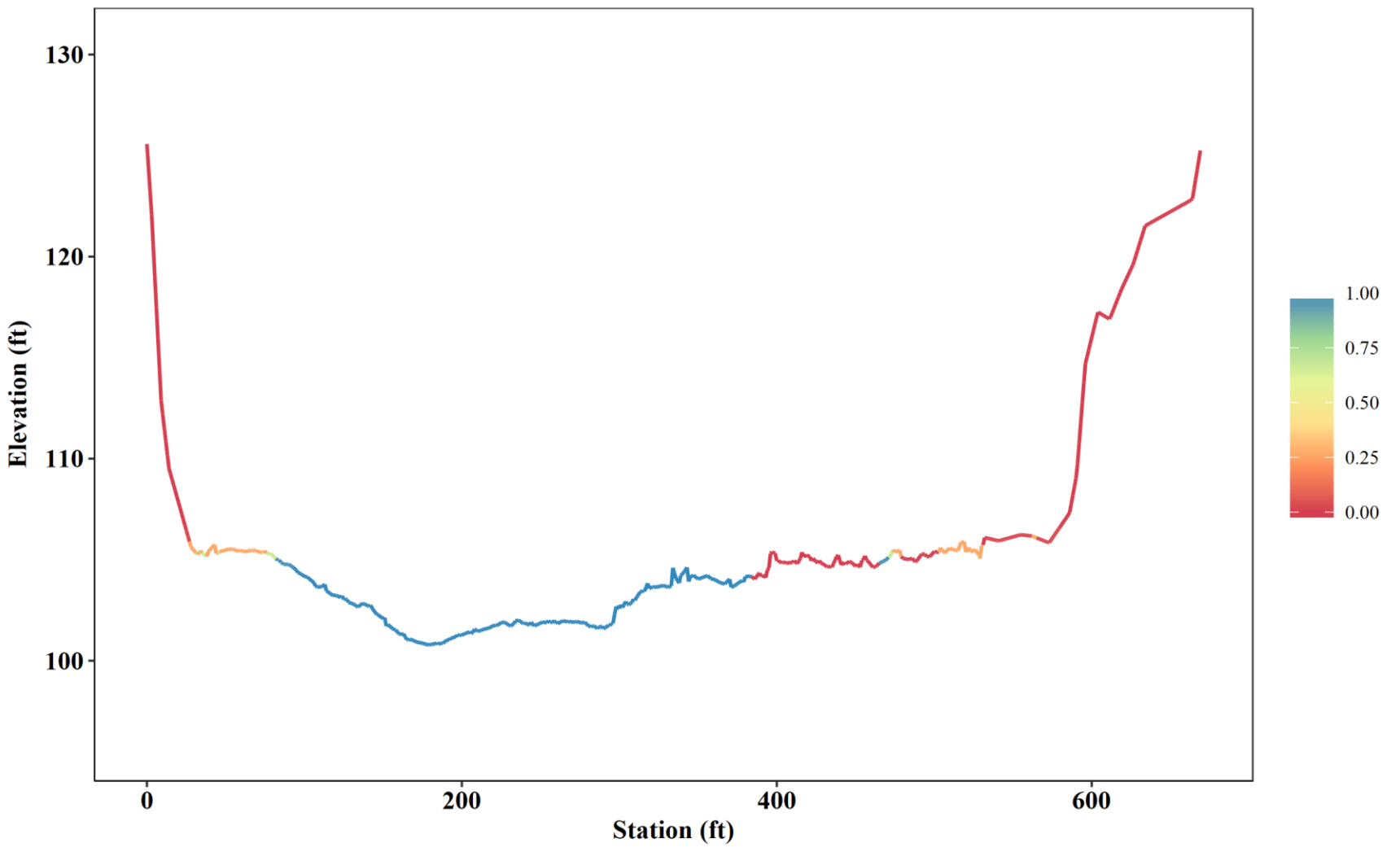

Figure D-20: Persistent Suitable Habitat Available to Proportions of Years for Adult Yellow Lampmussel (1962 through 2003) at T98 during ROR Operating Conditions.

Note: The colors along the transect profile indicate the proportions of years with persistent habitat available at a given location across the transect.

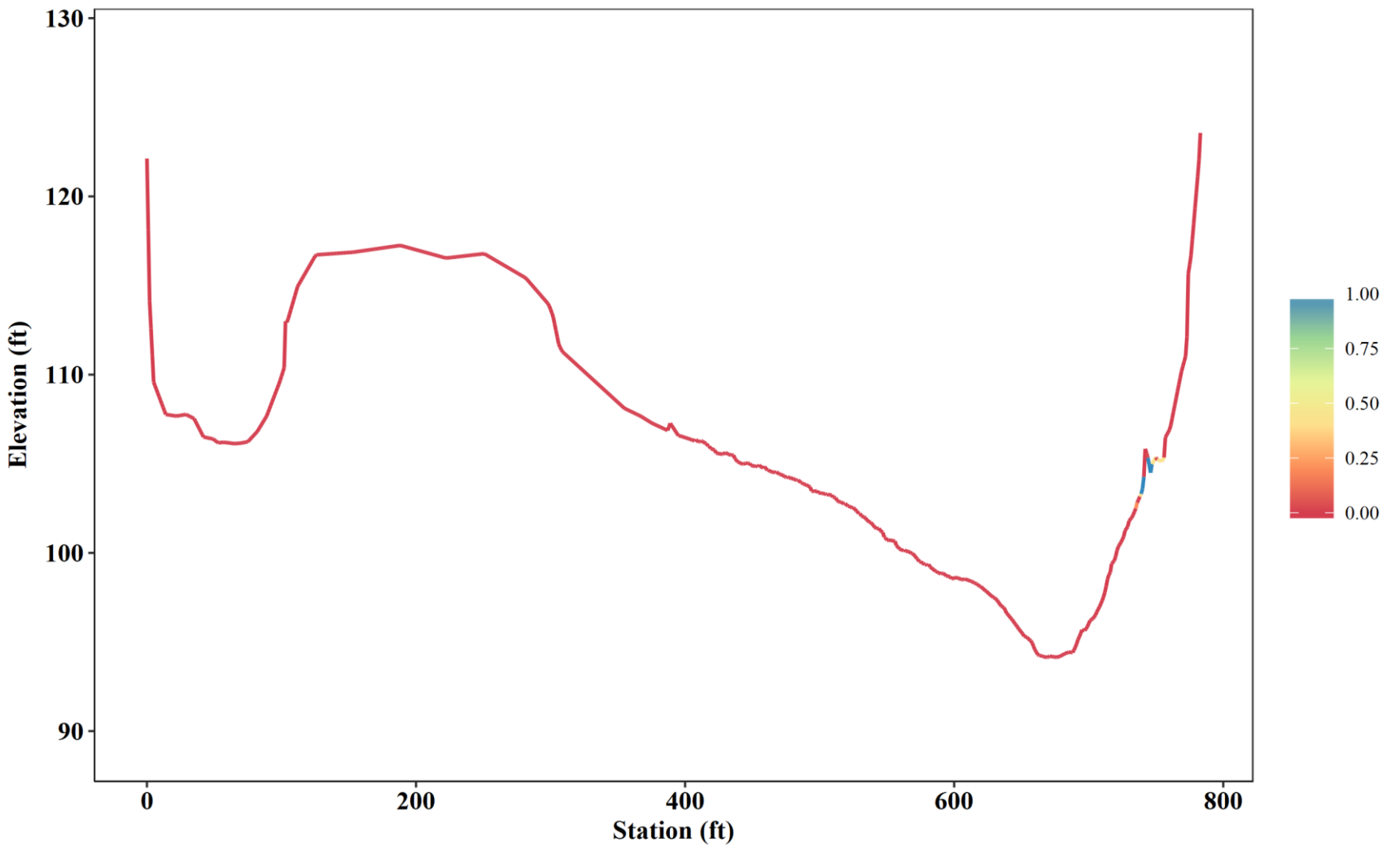

Figure D-21: Persistent Suitable Habitat Available to Proportions of 40 Juvenile Yellow Lampmussel 2-Year Cohorts (1962 through 2003) at T99 during ROR Operating Conditions.

Note: The colors along the transect profile indicate the proportions of cohorts with persistent habitat available at a given location across the transect.

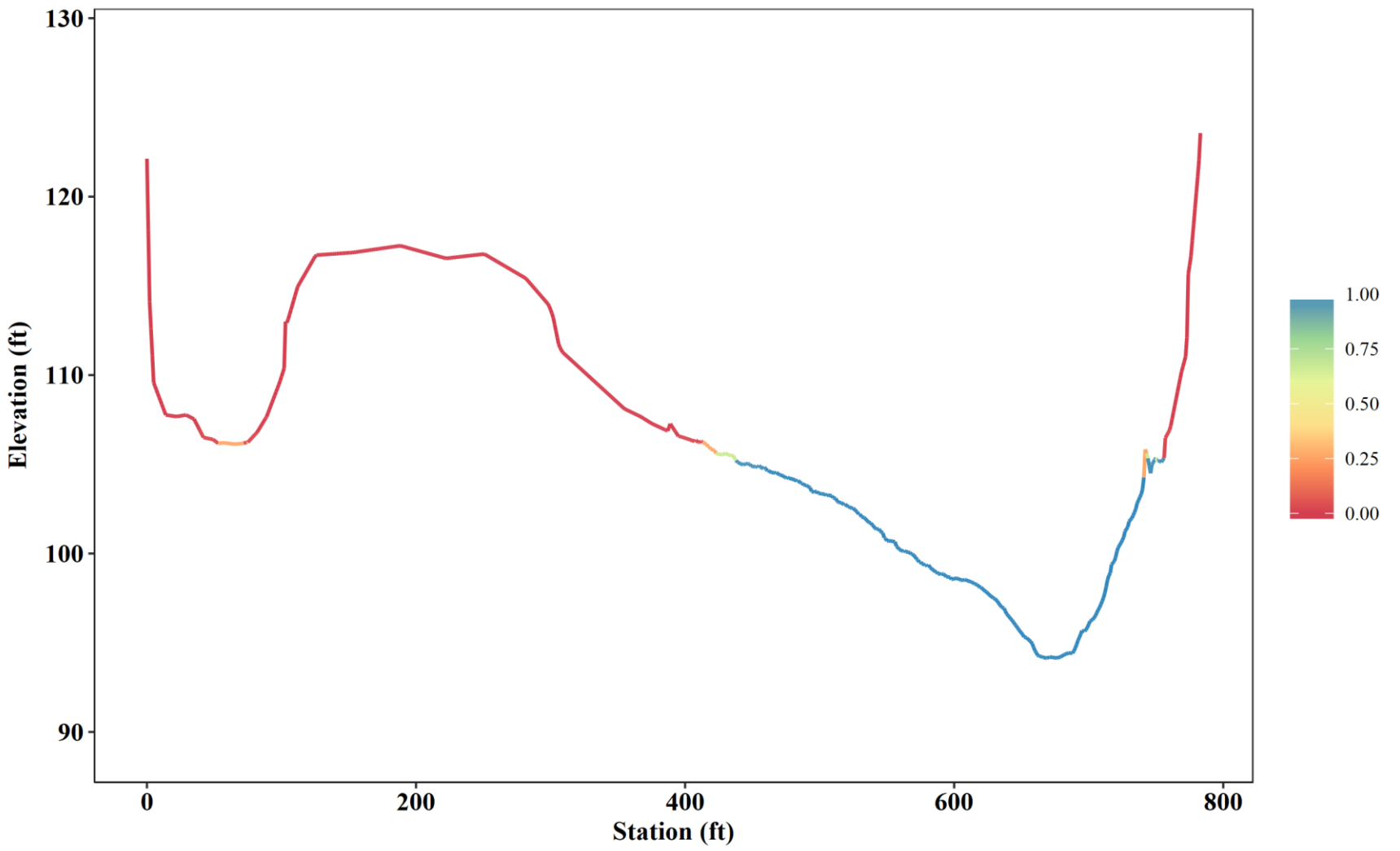

Figure D-22: Persistent Suitable Habitat Available to Proportions of Years for Adult Yellow Lampmussel (1962 through 2003) at T99 during ROR Operating Conditions.

Note: The colors along the transect profile indicate the proportions of years with persistent habitat available at a given location across the transect.

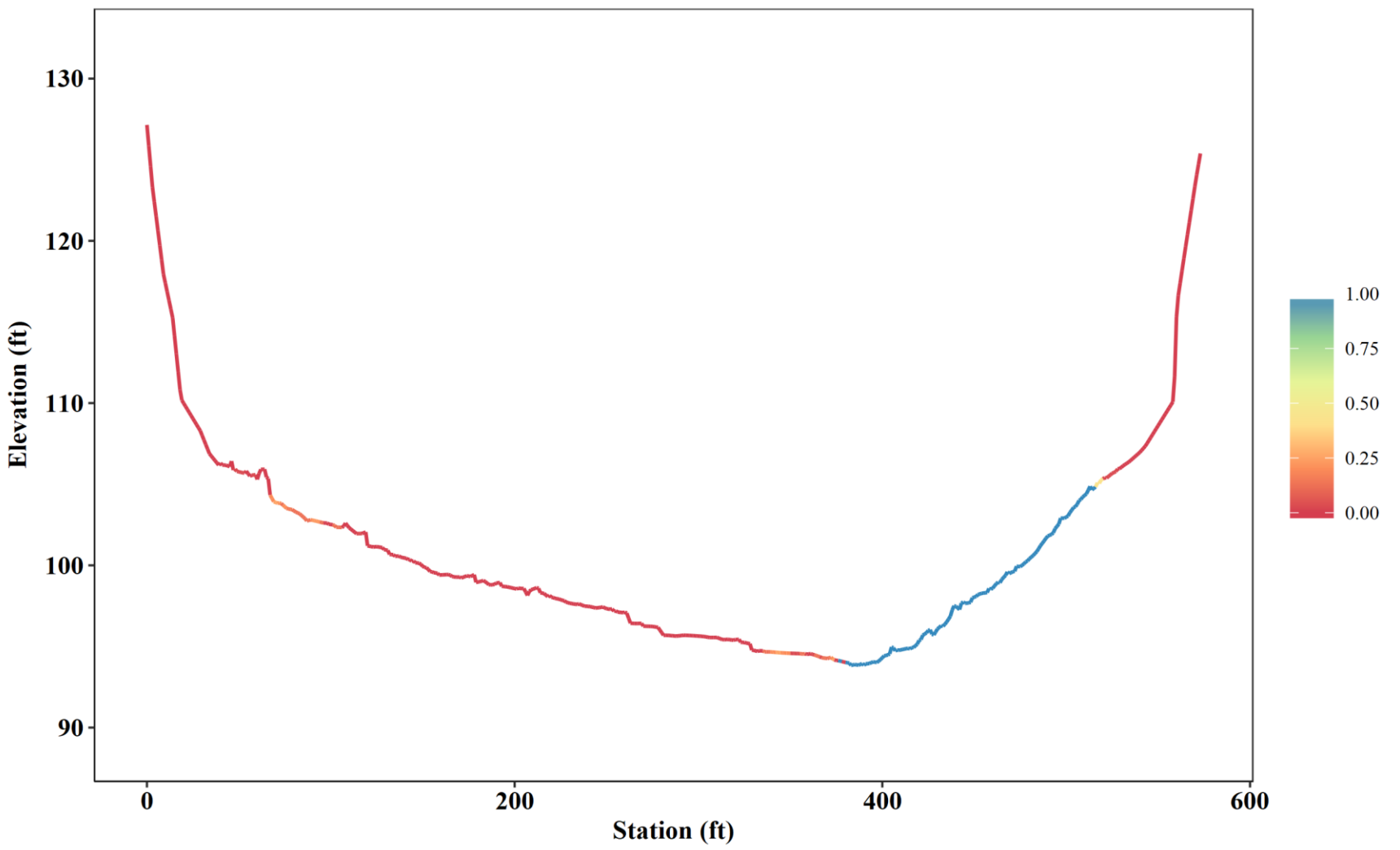

Figure D-23: Persistent Suitable Habitat Available to Proportions of 40 Juvenile Yellow Lampmussel 2-Year Cohorts (1962 through 2003) at T100 during ROR Operating Conditions.

Note: The colors along the transect profile indicate the proportions of cohorts with persistent habitat available at a given location across the transect.

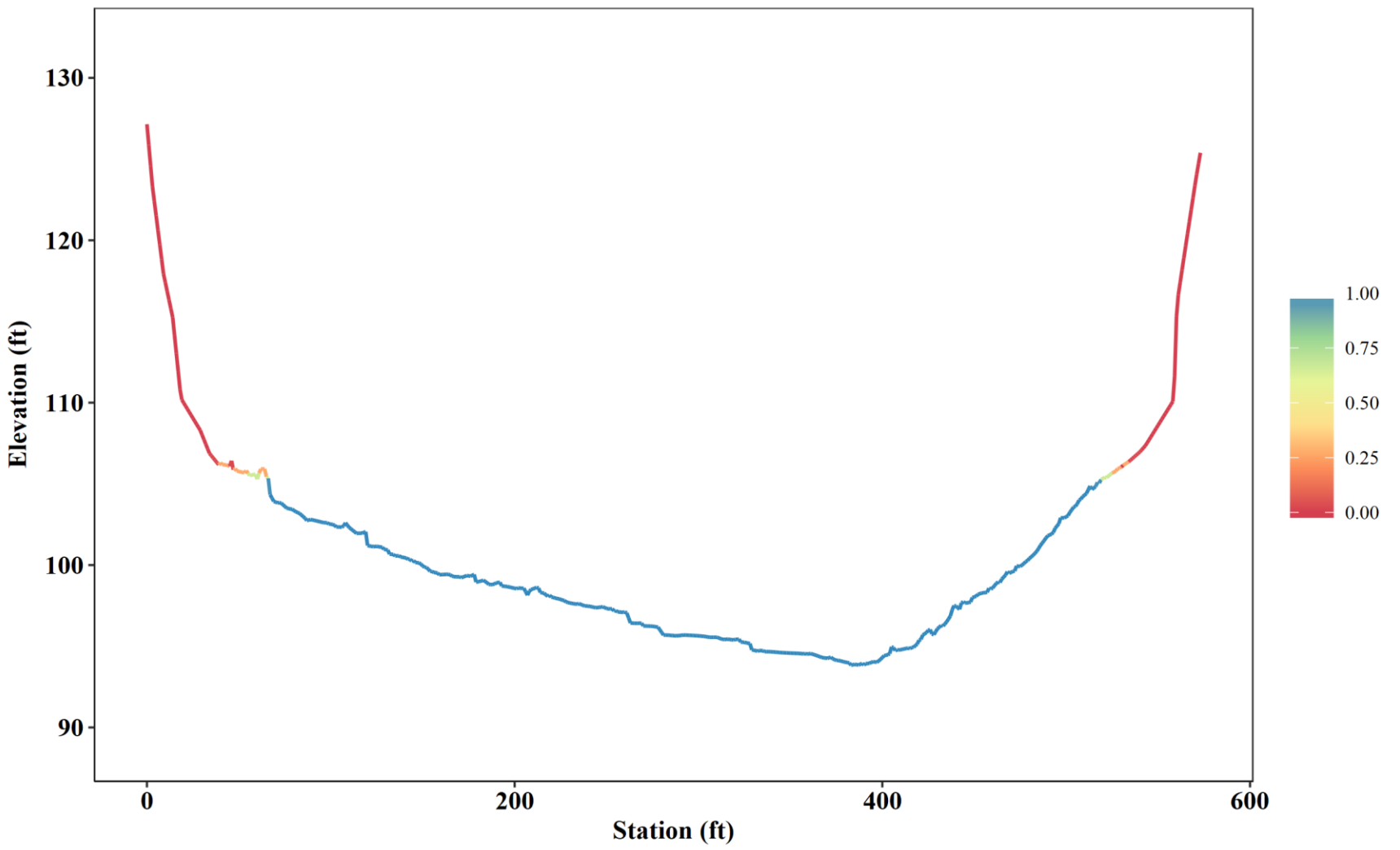

Figure D-24: Persistent Suitable Habitat Available to Proportions of Years for Adult Yellow Lampmussel (1962 through 2003) at T100 during ROR Operating Conditions.

Note: The colors along the transect profile indicate the proportions of years with persistent habitat available at a given location across the transect

APPENDIX E: SEA LAMPREY SPAWNING DUAL FLOW TABLES

Table E-1: Dual Flow Table of Total Reach 4 Suitable Area (sf) by WUA

CFS	1,200	1,600	2,000	2,800	4,000	5,000	6,000	8,000	10,000	12,000	14,000	15,000	17,500	20,000	25,000	30,000	37,500
1,200	5,267,755	4,974,038	4,556,461	3,798,351	2,944,437	2,333,223	1,887,091	1,152,866	644,631	312,260	158,010	117,978	29,208	2,146	1,789	2,146	1,073
1,600		5,709,779	5,239,636	4,394,940	3,395,142	2,723,864	2,208,390	1,383,174	792,931	416,987	247,631	201,807	78,188	10,374	3,577	3,935	1,789
2,000			5,781,006	4,910,881	3,834,326	3,101,367	2,551,498	1,624,438	943,982	520,724	332,892	278,853	133,194	21,490	0	0	0
2,800				5,843,156	4,641,306	3,809,528	3,182,473	2,110,626	1,251,645	703,985	472,718	407,949	239,257	84,421	1,431	715	0
4,000					5,488,736	4,605,224	3,918,438	2,668,636	1,619,269	904,954	580,900	502,758	329,347	148,466	6,136	0	0
5,000						5,032,642	4,316,946	2,984,529	1,838,262	1,025,313	648,578	561,121	373,567	189,233	17,817	2,504	2,146
6,000							4,604,984	3,232,002	2,000,253	1,121,402	706,804	602,795	394,410	206,073	22,082	358	0
8,000								3,512,234	2,213,453	1,281,206	806,690	670,830	424,417	233,121	47,342	14,542	3,577
10,000									2,354,779	1,386,456	882,965	738,699	484,347	287,342	77,239	38,509	8,227
12,000										1,482,682	972,903	824,606	565,012	342,403	122,710	71,460	6,315
14,000											1,063,900	910,595	640,655	415,308	164,204	76,234	7,870
15,000												974,859	703,846	475,279	175,527	79,811	9,300
17,500													779,599	542,447	185,419	83,622	11,323
20,000														556,440	194,238	89,098	13,222
25,000															201,956	92,648	14,625
30,000																98,386	19,290
37,500																	70,387

Table E-2: Dual Flow Table of Total Reach 4 Percent of Max Habitat by WUA

CFS	1,200	1,600	2,000	2,800	4,000	5,000	6,000	8,000	10,000	12,000	14,000	15,000	17,500	20,000	25,000	30,000	37,500
1,200	90%	85%	78%	65%	50%	40%	32%	20%	11%	5%	3%	2%	0%	0%	0%	0%	0%
1,600		98%	90%	75%	58%	47%	38%	24%	14%	7%	4%	3%	1%	0%	0%	0%	0%
2,000			99%	84%	66%	53%	44%	28%	16%	9%	6%	5%	2%	0%	0%	0%	0%
2,800				100%	79%	65%	54%	36%	21%	12%	8%	7%	4%	1%	0%	0%	0%
4,000					94%	79%	67%	46%	28%	15%	10%	9%	6%	3%	0%	0%	0%
5,000						86%	74%	51%	31%	18%	11%	10%	6%	3%	0%	0%	0%
6,000							79%	55%	34%	19%	12%	10%	7%	4%	0%	0%	0%
8,000								60%	38%	22%	14%	11%	7%	4%	1%	0%	0%
10,000									40%	24%	15%	13%	8%	5%	1%	1%	0%
12,000										25%	17%	14%	10%	6%	2%	1%	0%
14,000											18%	16%	11%	7%	3%	1%	0%
15,000												17%	12%	8%	3%	1%	0%
17,500													13%	9%	3%	1%	0%
20,000														10%	3%	2%	0%
25,000															3%	2%	0%
30,000																2%	0%
37,500																	1%

Table E-3: Dual Flow Table of Total Reach 4 Suitable Area (sf) by Quality WUA

CFS	1,200	1,600	2,000	2,800	4,000	5,000	6,000	8,000	10,000	12,000	14,000	15,000	17,500	20,000	25,000	30,000	37,500
1,200	4,168,884	3,854,099	3,414,116	2,785,213	1,278,226	701,112	118,044	0	0	0	0	0	0	0	0	0	0
1,600		4,793,646	4,315,690	3,557,889	1,916,969	1,098,183	311,208	14,308	0	0	0	0	0	0	0	0	0
2,000			4,996,717	4,228,185	2,572,957	1,733,120	900,191	314,785	0	0	0	0	0	0	0	0	0
2,800				5,069,647	3,400,111	2,545,966	1,702,305	948,621	175,278	0	0	0	0	0	0	0	0
4,000					4,253,399	3,374,215	2,523,400	1,717,434	631,776	64,388	0	0	0	0	0	0	0
5,000						3,840,902	2,982,933	2,144,774	978,077	125,337	8,943	0	0	0	0	0	0
6,000							3,244,591	2,399,277	1,152,094	268,673	27,929	0	0	0	0	0	0
8,000								2,705,544	1,376,085	414,101	119,975	52,283	0	0	0	0	0
10,000									1,517,602	522,872	225,170	110,975	54,014	43,283	0	0	0
12,000										566,155	268,452	154,258	97,297	43,283	0	0	0
14,000											309,947	195,752	124,483	70,469	0	0	0
15,000												373,176	301,907	247,893	11,804	0	0
17,500													380,961	298,330	27,544	0	0
20,000														309,612	36,486	8,943	0
25,000															36,486	8,943	0
30,000																16,097	0
37,500																	0

Table E-4: Dual Flow Table of Total Reach 4 Percent of Max Habitat by Quality WUA

CFS	1,200	1,600	2,000	2,800	4,000	5,000	6,000	8,000	10,000	12,000	14,000	15,000	17,500	20,000	25,000	30,000	37,500
1,200	82%	76%	67%	55%	25%	14%	2%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1,600		95%	85%	70%	38%	22%	6%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2,000			99%	83%	51%	34%	18%	6%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2,800				100%	67%	50%	34%	19%	3%	0%	0%	0%	0%	0%	0%	0%	0%
4,000					84%	67%	50%	34%	12%	1%	0%	0%	0%	0%	0%	0%	0%
5,000						76%	59%	42%	19%	2%	0%	0%	0%	0%	0%	0%	0%
6,000							64%	47%	23%	5%	1%	0%	0%	0%	0%	0%	0%
8,000								53%	27%	8%	2%	1%	0%	0%	0%	0%	0%
10,000									30%	10%	4%	2%	1%	1%	0%	0%	0%
12,000										11%	5%	3%	2%	1%	0%	0%	0%
14,000											6%	4%	2%	1%	0%	0%	0%
15,000												7%	6%	5%	0%	0%	0%
17,500													8%	6%	1%	0%	0%
20,000														6%	1%	0%	0%
25,000															1%	0%	0%
30,000																0%	0%
37,500																	0%