

Differences by Generation in Oregon Hunting & Fishing License Holder Retention

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Oregon
Department of
Fish and
Wildlife

Background: The North American Model of Wildlife Conservation

- The North American Model of Wildlife Conservation (NAMWC) was developed in the early 1900's in response to resource exploitation and over-harvesting of North America's fish and wildlife by "market hunters" during the industrial revolution (Organ et al. 2012).
- Tenets of the NAMWC include the characterization of wildlife as a public trust resource and prohibition on commerce of dead wildlife (U.S. Fish and Wildlife Service 2022).
 - The Lacey Act of 1900: Prohibits trade in wildlife, fish, and plants that have been illegally taken, possessed, transported, or sold.



Bison skulls piled in the Midwest in the mid-1870s. Image Source: Wikipedia Commons

Background: The North American Model of Wildlife Conservation

- By the 1920's, early conservationists recognized the need for a program of restoration to augment conservation's legal framework, calling for a wildlife management profession with trained biologists and stable, equitable funding to enable their work (Organ et al. 2012).
- Funding would come from hunting and fishing license and permit fees administered by state fish and wildlife management agencies in addition to federal excise taxes on hunting, shooting, boating, and fishing gear (Organ et al. 2012).
 - (Pittman-Robertson Act of 1937, Dingell-Johnson Act of 1950).

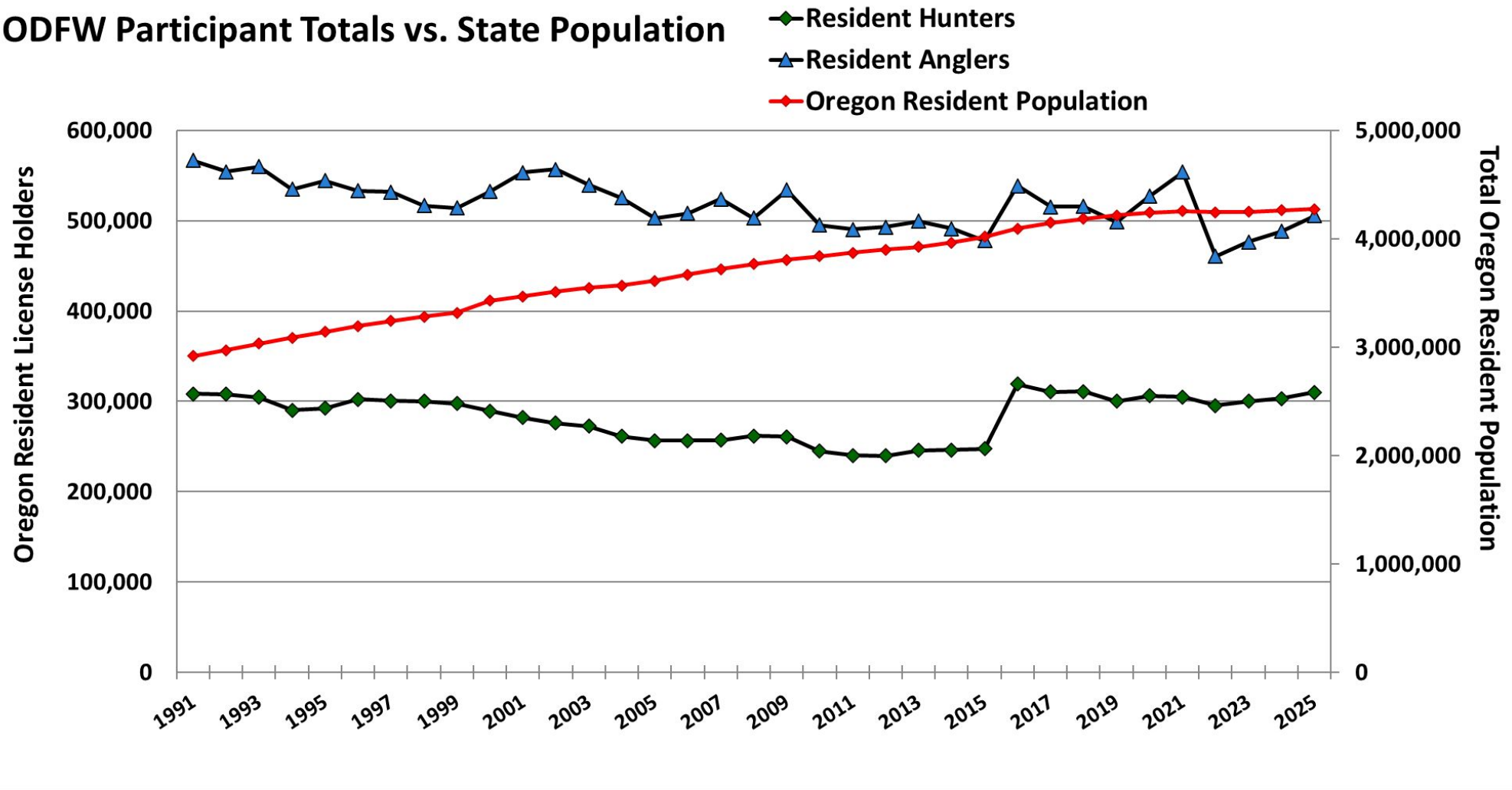


Untitled [Thomas Hills poses with two trophy elk] Mounted silver gelatin print
Photographer unknown, Manitoba, Canada, ca. 1900 2003.093

Background: The North American Model of Wildlife Conservation

- The funding mechanisms of the NAMWC characterize it as a “user-pay, user-benefit” model. Sportsman-derived funds comprise between 60 and 90 percent of the typical state fish and wildlife agency budget (Organ et al. 2012).
- Declining hunting and fishing participation rates observed in the U.S. since the 1990s have raised questions about the long-term viability of these funding mechanisms (U.S. Fish and Wildlife Service 2018).
- Differences in participation rates for younger generations are particularly important to understand, as these generations represent the future of wildlife conservation and management funding in the U.S. under the NAMWC (Winkler and Warnke 2013, Burkett and Winkler 2018, Mohr et al. 2025).

ODFW Participant Totals vs. State Population



- State population data source: U.S. Census Bureau, Resident Population in Oregon [ORPOP], retrieved from FRED, Federal Reserve Bank of St. Louis; <https://fred.stlouisfed.org/series/ORPOP>, March 27, 2026.

Study Objectives

- Determine whether differences exist in hunting, fishing, or combination license holder retention and reactivation probabilities across generations for ODFW license holders.
- Evaluate effectiveness of discrete time Markov modelling as an approach to identify differences in these probabilities across generations.
- If differences exist, identify generation/license category groups that could be targeted for outreach geared towards improving retention and reactivation probabilities.
- Consider possible implications of any identified differences on long-term viability of the current NAMWC for funding wildlife management in Oregon.

Data: 2019 Cohort Participation Overview

§ We begin with data on all resident license holders in 2019 and track this same cohort's purchase behaviors through 2024.

§ Participation in each year was categorized into one of the following mutually exclusive "states":

§ A: Angler Only

§ C: Combination

§ H: Hunter Only

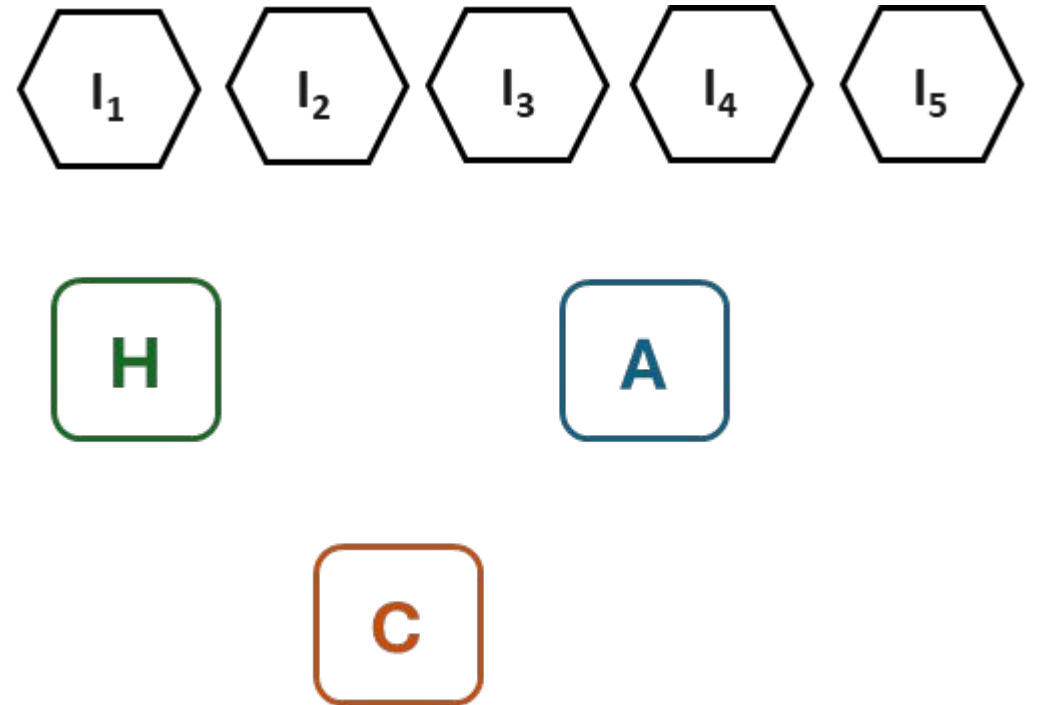
§ I1: Inactive for 1 year

§ I2: Inactive for 2 consecutive years

§ I3: Inactive for 3 consecutive years

§ I4: Inactive for 4 consecutive years

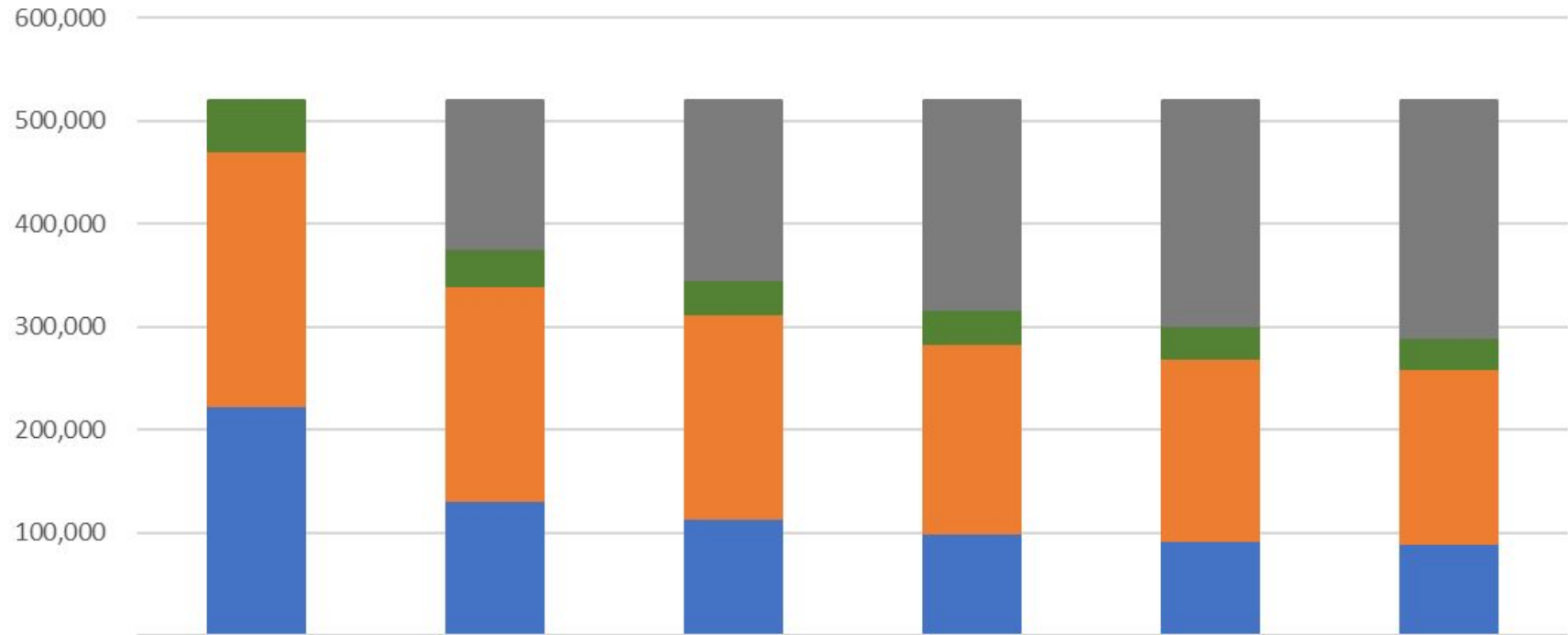
§ I5: Inactive for 5 consecutive years



Data: 2019 Cohort by Generations

- We subset the 2019 license holder cohort by date of birth (year) into groups corresponding to the following U.S. Census Bureau definitions:
 - Greatest Generation: born in 1927 or earlier (n=1,133)
 - Silent Generation: born 1928-1945 (n=56,163)
 - Baby Boomers: born 1946-1964 (n=157,162)
 - Gen X: born 1965-1980 (n=132,810)
 - Millennials: born 1981-1996 (n=116,984)
 - Gen Z: born 1997-2012 (n=56,566)
 - Gen Alpha: born 2013-current (n=50)
- The sample sizes for the Greatest Generation (n=1,133) and Gen Alpha (n=50) were too small for statistically meaningful analysis; these observations were dropped from the dataset.

2019 Cohort Participation Over Time



	2019	2020	2021	2022	2023	2024
■ Total Inactive	-	143,073	173,309	202,951	218,184	229,946
■ Hunting Only (H)	48,685	36,679	34,453	33,591	32,517	30,188
■ Combination (C)	248,184	208,973	198,241	183,452	176,220	170,172
■ Angler Only (A)	222,816	130,960	113,682	99,691	92,764	89,379

Markov Chain Model Overview

- A discrete time Markov chain model (DTMC) is a stochastic process whose domain is a set of discrete states (Spedicato 2017).
- DTMCs rely on Markov Assumptions (Markov Properties):
 - Memoryless Property: an object's state in future period "t+1" depends only on its state in the current period "t".
 - Time-homogeneity: the probability of moving from any given state to another is constant over time.
- Maximum likelihood estimator method (MLE) was used to fit the probability matrix for each generation.
- Outputs a matrix describing conditional probabilities of moving from any state in period "t" to any other state in period "t+1".
- Model fit was assessed through simulation-based model checking, a method described as being “similar to posterior predictive checking under a Bayesian framework” (Gelman and Shalizi 2013, Hinrichs et al. 2020).

Results: Tests for Model Fit/Accuracy

Generation	RMSE	R ²	MAPE
Silent Generation	1248.56	0.98	11.22%
Baby Boomers	3250.97	0.97	12.47%
Gen X	2854.93	0.95	12.67%
Millenials	3006.60	0.90	13.82%
Gen Z	2173.62	0.91	25.91%

- High MAPE for the Gen Z subset indicative of a poorer model fit, possibly a violation of Markov assumption of time-homogeneity.
- Potentially a result of ODFW license structure; a Youth Combination License is offered at a highly discounted cost to children under the age of 18.
- Transition probability matrices for Gen Z are therefore excluded from the final analysis.

Results: Retention Probabilities by Generation

From Group	To Group	Silent Generation (1928-1945)		Baby Boomers (1946-1964)		Gen X (1965-1980)		Millenials (1981-1996)	
		± 95% CI		± 95% CI		± 95% CI		± 95% CI	
A	A	0.63	0.0083	0.65	0.0033	0.62	0.0034	0.52	0.0035
A	C	0.06	0.0025	0.07	0.0011	0.06	0.0010	0.08	0.0013
A	H	0.00	0.0003	0.00	0.0002	0.01	0.0003	0.01	0.0005
C	A	0.01	0.0004	0.03	0.0006	0.05	0.0010	0.07	0.0012
C	C	0.80	0.0044	0.85	0.0032	0.81	0.0038	0.75	0.0041
C	H	0.00	0.0003	0.03	0.0006	0.07	0.0011	0.09	0.0014
H	A	0.01	0.0029	0.01	0.0011	0.02	0.0012	0.03	0.0014
H	C	0.16	0.0131	0.23	0.0043	0.23	0.0038	0.25	0.0038
H	H	0.57	0.0245	0.60	0.0069	0.58	0.0061	0.52	0.0056

Results: Inactivity Probabilities by Generation

From Group	To Group	Silent Generation (1928-1945)		Baby Boomers (1946-1964)		Gen X (1965-1980)		Millenials (1981-1996)	
		± 95% CI		± 95% CI		± 95% CI		± 95% CI	
A	I1	0.31	0.006	0.27	0.002	0.32	0.002	0.39	0.003
C	I1	0.19	0.002	0.09	0.001	0.07	0.001	0.09	0.001
H	I1	0.26	0.016	0.16	0.004	0.16	0.003	0.20	0.003

Results: Reactivation Probabilities by Generation

From Group	To Group	Silent Generation (1928-1945)		Baby Boomers (1946-1964)		Gen X (1965-1980)		Millenials (1981-1996)	
		± 95% CI		± 95% CI		± 95% CI		± 95% CI	
I1	A	0.06	0.002	0.18	0.003	0.21	0.003	0.18	0.003
I1	C	0.16	0.004	0.11	0.002	0.06	0.002	0.06	0.002
I1	H	0.00	0.001	0.02	0.001	0.04	0.001	0.05	0.002
I1	I2	0.77	0.009	0.69	0.006	0.69	0.006	0.71	0.006
I2	A	0.02	0.002	0.10	0.003	0.12	0.003	0.11	0.003
I2	C	0.07	0.003	0.05	0.002	0.02	0.001	0.03	0.001
I2	H	0.00	0.001	0.01	0.001	0.02	0.001	0.02	0.001
I2	I3	0.90	0.012	0.84	0.008	0.83	0.008	0.84	0.008
I3	A	0.01	0.002	0.07	0.003	0.08	0.003	0.08	0.003
I3	C	0.04	0.003	0.03	0.002	0.01	0.001	0.01	0.001
I3	H	0.00	0.001	0.01	0.001	0.01	0.001	0.02	0.001
I3	I4	0.94	0.015	0.90	0.010	0.89	0.011	0.89	0.010
I4	A	0.01	0.002	0.05	0.003	0.06	0.004	0.06	0.003
I4	C	0.03	0.003	0.02	0.002	0.01	0.001	0.01	0.001
I4	H	0.00	0.001	0.00	0.001	0.01	0.001	0.01	0.001
I4	I5	0.96	0.019	0.93	0.013	0.92	0.013	0.93	0.013

Conclusion – High-level Takeaways

- Discrete-time Markov chain model was an effective method for identifying whether differences exist in retention and reactivation rates across generations, though likely violation of the assumption of time-homogeneity prevented accurate estimation of retention/reactivation rates for Gen Z participants.
 - This method could be applied by other state fish and wildlife agencies using readily accessible licensing data to answer similar questions, though care should be taken to ensure that the Markov assumption of time-homogeneity is not violated.
- Differences exist across generations in Oregon hunting, fishing, and combination license holder retention probabilities; smaller differences observed in reactivation probabilities.
 - Younger (Millennial) “Hunting Only” and “Angling Only” participants had higher probabilities of becoming inactive compared to their older (Silent Generation, Baby Boomers, and Gen X) counterparts.
 - Millennial “Combination” participants had similar probabilities of becoming inactive compared to Baby Boomers and Gen X.

Conclusion – Policy Implications

- Millennial anglers had the highest probability of becoming inactive of any participation/generation subset, suggesting state fish and wildlife agencies could benefit from focusing more efforts on retention aimed at younger generations of anglers.
- Combination participants were most likely to be retained across all generations. Incentivizing this type of participation and developing pathways for “Angling Only” or “Hunting Only” participants to become “Combination” participants may result in higher overall license holder retention.
 - Millennial hunters and anglers had the highest probabilities of switching to combination participation.
- The probability of continued inactivity spiked in year 2 of consecutive inactivity for all generations, highlighting the importance of conducting outreach or other means of incentivizing reactivation during the first year or two of inactivity for any former license holder.

Conclusion – Policy Implications

- While this research identified differences in retention rates across generations, DTMCs cannot discern whether these differences are due to “age effects” or “cohort effects”.
 - Lower retention rates due to cohort effects would have more negative implications for the long-term viability of wildlife conservation and restoration funding under the NAMWC.
- Policymakers should nonetheless be cognizant of the lower retention rates observed for Millennials in this study and open to considering ways to augment the NAMWC should future research identify cohort effects negatively impacting hunting and fishing participation in younger generations.
 - Exploring avenues for generating revenue from non-consumptive uses (wildlife watching, etc.) could be beneficial.

Future Work

- Conduct Age-Period-Cohort analysis to determine whether age effects or cohort effects are driving the differences in retention/reactivation probabilities across generations.
- Incorporate the effects of path dependence on retention/reactivation probabilities.
- Incorporate recruitment into a model of license holder purchase behaviors alongside reactivation/retention.
 - Mark-recapture models (Gude et al. 2012, Schorr et al. 2014)
 - Multistate models (Nichols 2019)
 - State-structured matrix models (Price Tack et al. 2018)
 - Integrated population models (Riecke et al. 2019)

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Thank you all for listening!

- Questions/Comments/Suggestions?

Appendix: Supporting Literature

- **National trends in hunting and fishing participation rates.**

- U.S. Fish and Wildlife Service. 2018. 2016 national survey of fishing, hunting, and wildlife-associated recreation. U.S. Fish and Wildlife Service, Washington, D.C., USA.

- **Markov Chain Models: Theory and applications.**

- Grewal, J. K., Krzywinski, M., & Altman, N. (2019). Markov models--Markov chains. *Nature Methods*, 16, 663+. <http://dx.doi.org.slo.idm.oclc.org/10.1038/s41592-019-0476-x>
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- **Impacts of age on hunting and fishing participation rates.**

- Burkett, E. M., & Winkler, R. L. (2019). Recreational fishing participation trends in Upper Great Lakes States: an age-period-cohort analysis. *Human Dimensions of Wildlife*, 24(1), 95–97. <https://doi.org/10.1080/10871209.2018.1526352>
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- **Markov Chain Models applied to hunting and fishing license holder data.**

- Hinrichs, M. P., Price, N. B., Gruntorad, M. P., Pope, K. L., Fontaine, J. J., & Chizinski, C. J. (2020). Understanding Sportsperson Retention and Reactivation Through License Purchasing Behavior. *Wildlife Society Bulletin*, 44(2), 383–390. <https://doi.org/https://doi.org/10.1002/wsb.1088>

Appendix: 2019 Cohort Overall Participation Summary Statistics

	2019	2020	2021	2022	2023	2024
Angler Only (A)	222,816	130,960	113,682	99,691	92,764	89,379
Combination (C)	248,184	208,973	198,241	183,452	176,220	170,172
Hunting Only (H)	48,685	36,679	34,453	33,591	32,517	30,188
Inactive 1 Year (I1)	-	143,073	65,960	62,951	52,085	48,119
Inactive 2 Years (I2)	-	-	107,349	46,238	42,819	34,460
Inactive 3 Years (I3)	-	-	-	93,762	38,052	34,761
Inactive 4 Years (I4)	-	-	-	-	85,228	33,340
Inactive 5 Years (I5)	-	-	-	-	-	79,266
Total	519,685	519,685	519,685	519,685	519,685	519,685
Total Active	519,685	376,612	346,376	316,734	301,501	289,739
Total Inactive	-	143,073	173,309	202,951	218,184	229,946

- Note: Gen Alpha participants (n=50) and Greatest Generation participants (n=1133) not included in these totals.

Appendix Results: Retention Probabilities by Generation Including Gen Z

From Group	To Group	Silent Generation (1928-1945)		Baby Boomers (1946-1964)		Gen X (1965-1980)		Millenials (1981-1996)		Gen Z (1997-2012)	
		± 95% CI		± 95% CI		± 95% CI		± 95% CI		± 95% CI	
A	A	0.63	0.0083	0.65	0.0033	0.62	0.0034	0.52	0.0035	0.43	0.0077
A	C	0.06	0.0025	0.07	0.0011	0.06	0.0010	0.08	0.0013	0.12	0.0041
A	H	0.00	0.0003	0.00	0.0002	0.01	0.0003	0.01	0.0005	0.01	0.0013
C	A	0.01	0.0004	0.03	0.0006	0.05	0.0010	0.07	0.0012	0.05	0.0012
C	C	0.80	0.0044	0.85	0.0032	0.81	0.0038	0.75	0.0041	0.68	0.0043
C	H	0.00	0.0003	0.03	0.0006	0.07	0.0011	0.09	0.0014	0.03	0.0010
H	A	0.01	0.0029	0.01	0.0011	0.02	0.0012	0.03	0.0014	0.04	0.0041
H	C	0.16	0.0131	0.23	0.0043	0.23	0.0038	0.25	0.0038	0.26	0.0107
H	H	0.57	0.0245	0.60	0.0069	0.58	0.0061	0.52	0.0056	0.46	0.0141

Appendix Results: Inactivity Probabilities by Generation Including Gen Z

From Group	To Group	Silent Generation (1928-1945)		Baby Boomers (1946-1964)		Gen X (1965-1980)		Millenials (1981-1996)		Gen Z (1997-2012)	
		± 95% CI		± 95% CI		± 95% CI		± 95% CI		± 95% CI	
A	I1	0.31	0.006	0.27	0.002	0.32	0.002	0.39	0.003	0.43	0.008
C	I1	0.19	0.002	0.09	0.001	0.07	0.001	0.09	0.001	0.24	0.003
H	I1	0.26	0.016	0.16	0.004	0.16	0.003	0.20	0.003	0.24	0.010

Appendix Results: Reactivation Probabilities by Generation Including Gen Z

From Group	To Group	Silent Generation (1928-1945)		Baby Boomers (1946-1964)		Gen X (1965-1980)		Millenials (1981-1996)		Gen Z (1997-2012)	
		± 95% CI	± 95% CI	± 95% CI	± 95% CI	± 95% CI	± 95% CI	± 95% CI	± 95% CI		
I1	A	0.06	0.002	0.18	0.003	0.21	0.003	0.18	0.003	0.10	0.003
I1	C	0.16	0.004	0.11	0.002	0.06	0.002	0.06	0.002	0.14	0.003
I1	H	0.00	0.001	0.02	0.001	0.04	0.001	0.05	0.002	0.02	0.001
I1	I2	0.77	0.009	0.69	0.006	0.69	0.006	0.71	0.006	0.75	0.008
I2	A	0.02	0.002	0.10	0.003	0.12	0.003	0.11	0.003	0.07	0.003
I2	C	0.07	0.003	0.05	0.002	0.02	0.001	0.03	0.001	0.07	0.003
I2	H	0.00	0.001	0.01	0.001	0.02	0.001	0.02	0.001	0.01	0.001
I2	I3	0.90	0.012	0.84	0.008	0.83	0.008	0.84	0.008	0.85	0.011
I3	A	0.01	0.002	0.07	0.003	0.08	0.003	0.08	0.003	0.06	0.003
I3	C	0.04	0.003	0.03	0.002	0.01	0.001	0.01	0.001	0.04	0.003
I3	H	0.00	0.001	0.01	0.001	0.01	0.001	0.02	0.001	0.01	0.001
I3	I4	0.94	0.015	0.90	0.010	0.89	0.011	0.89	0.010	0.89	0.013
I4	A	0.01	0.002	0.05	0.003	0.06	0.004	0.06	0.003	0.05	0.004
I4	C	0.03	0.003	0.02	0.002	0.01	0.001	0.01	0.001	0.02	0.002
I4	H	0.00	0.001	0.00	0.001	0.01	0.001	0.01	0.001	0.01	0.001
I4	I5	0.96	0.019	0.93	0.013	0.92	0.013	0.93	0.013	0.93	0.017

Appendix: Markov Transition Probabilities by Demographics - Gender

Markov Probability Matrix (Resident Male Participants)

		t+1							
		A	C	H	I1	I2	I3	I4	I5
t	A	62%	8%	1%	30%	-	-	-	-
	C	4%	81%	4%	11%	-	-	-	-
	H	3%	26%	54%	18%	-	-	-	-
	I1	17%	10%	3%	-	70%	-	-	-
	I2	10%	5%	1%	-	-	84%	-	-
	I3	7%	3%	1%	-	-	-	89%	-
	I4	5%	2%	1%	-	-	-	-	93%
	I5	-	-	-	-	-	-	-	-

Markov Probability Matrix (Resident Female Participants)

		t+1							
		A	C	H	I1	I2	I3	I4	I5
t	A	55%	5%	1%	39%	-	-	-	-
	C	4%	71%	6%	18%	-	-	-	-
	H	2%	18%	62%	19%	-	-	-	-
	I1	15%	7%	3%	-	75%	-	-	-
	I2	8%	3%	1%	-	-	87%	-	-
	I3	6%	2%	1%	-	-	-	91%	-
	I4	4%	1%	1%	-	-	-	-	94%
	I5	-	-	-	-	-	-	-	-

Markov State Summary Statistics (Resident Male Participants)

	2019	2020	2021	2022	2023	2024
A	159,170	97,870	86,352	76,990	72,067	69,947
C	202,735	174,321	166,645	155,036	149,590	144,796
H	35,122	26,405	24,644	23,879	23,149	21,321
I1	-	98,431	47,125	46,257	38,414	35,663
I2	-	-	72,261	32,424	31,041	25,094
I3	-	-	-	62,441	26,442	25,061
I4	-	-	-	-	56,324	23,023
I5	-	-	-	-	-	52,122
Total	397,027	397,027	397,027	397,027	397,027	397,027
Total Inactive	-	98,431	119,386	141,122	152,221	160,963

Markov State Summary Statistics (Resident Female Participants)

	2019	2020	2021	2022	2023	2024
A	63,624	33,100	27,331	22,702	20,693	19,420
C	46,297	35,149	31,959	28,666	26,790	25,489
H	13,569	10,271	9,807	9,705	9,363	8,864
I1	-	44,970	19,008	16,832	13,767	12,512
I2	-	-	35,385	13,966	11,914	9,455
I3	-	-	-	31,619	11,761	9,835
I4	-	-	-	-	29,202	10,471
I5	-	-	-	-	-	27,444
Total	123,490	123,490	123,490	123,490	123,490	123,490
Total Inactive	-	44,970	54,393	62,417	66,644	69,717

