Columbian White-Tailed Deer
(*Odocoileus virginianus leucurus*)
Population and Habitat Viability Assessment

WORKSHOP REPORT

Columbian White-Tailed Deer (*Odocoileus virginianus leucurus*) Columbia River Distinct Population Segment

Population and Habitat Viability Assessment

24 – 26 April, 2018
1 August, 2018
Ridgefield, WA

Workshop Organization and Support:
Washington Department of Fish and Wildlife

Workshop Design and Facilitation:
IUCN/SSC Conservation Planning Specialist Group

A contribution of the IUCN/SSC Conservation Planning Specialist Group, in collaboration with the Washington Department of Fish and Wildlife and workshop participants.

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Preface

This report documents discussions, analyses, deliberations, and decisions undertaken by workshop participants under a conservation planning project for Columbian white-tailed deer (CWTD) requested by the Washington Department of Fish and Wildlife (WDFW) and facilitated by the IUCN's Conservation Planning Specialist Group (CPSG). The project was formally initiated in October 2017 with the implementation of a population viability analysis (PVA), which was followed by a Population and Habitat Viability Assessment (PHVA) workshop in April 2018. A smaller follow-up meeting was held in August 2018 in an attempt to finish parts of the tasks that could not be completed at the April workshop. The publication and distribution of this workshop process final report in February 2020 signals the completion of the project.

The reader will note some significant differences in presentation between the two working group reports beginning on page 75. While both groups were provided with the same instructions for their internal discussions and subsequent reporting of their analysis and decisions, they did not document the results of their work with equivalent detail. As a result, the report editors were unable to incorporate additional material into the appropriate working group reports.

While this document retains value as a collection of guidelines and recommendations for successful management of Columbian white-tailed deer that make up the Columbia River distinct population segment (DPS), it is unfortunate and regrettable that the final product is completed approximately 18 months after the final workshop was conducted. As a result of this delay, there is no doubt that some of the information contained herein is now out of date.

CPSG's policy for dealing with this situation is to maintain the integrity of the original workshop report as an accurate representation of information analysis and decision-making as of the date that the workshop was conducted. Given this policy, we can use this section of the report to outline important new information that has emerged since the PVA and PHVA workshops were held. This list will almost certainly not be exhaustive, but will hopefully capture the most important updates of data and/or information that was assembled for the analyses captured in this report.

Important updates include:

1. Recent subpopulation survey data (as of late 2019) includes evidence for a significant increase in CWTD abundance on Cottonwood Island to as many as 100 individuals. This estimate is much higher than the ecological carrying capacity estimate (K = 52) used in the 2018-2019 PVA for the entire Wasser – Winter / Kalama subpopulation unit that includes Cottonwood Island (see Figure 1 on page 8 for more information). The abundance estimate could represent an island population that is approaching a carrying capacity that was grossly underestimated in the original analysis, which could impact our predictions for the long-term stability of what was originally thought to be a relatively small population that could be demographically or genetically fragile. On the other hand, this high abundance estimate could represent a population that has temporarily greatly exceeded the carrying capacity for the island habitat in response to favorable ecological conditions in the short-term, and will likely return to a smaller, more manageable abundance

when resources become limiting. A meaningful interpretation of this observation will likely require additional monitoring data for Cottonwood Island, perhaps over the next two to three years.

2. Translocation of deer from Tennasillahe to the Columbia Stock Ranch began in 2020. The original goal was to translocate 30 individuals; delays due to weather complications and the presence of adenovirus hemorrhagic disease (AHD) among deer near the release site led to a revised goal of translocating 20 deer in 2020, with 20 – 30 individuals targeted for translocation in 2021. As of February 2020, a total of 12 deer have been translocated, with one individual dying due to trauma that was considered unrelated to the translocation event itself.

3. During the ongoing translocation process described above, managers are now collecting DNA samples from translocated deer to evaluate the extent of potential hybridization with black-tailed deer. This information is directly relevant to addressing Action 5.3 outlined by the Population Working Group in their report on page 83 of this document. This sampling process will be ongoing as translocation efforts continue.

4. Reports of deer mortality in three counties (Multnomah, Columbia, and Yamhill) adjacent to the Northern Oregon portion of Columbian white-tailed deer distribution were received by the Oregon Department of Fish and Wildlife (ODFW) North Willamette Watershed District between 25 October and 10 December, 2019:
    a. Six mortalities were investigated by ODFW staff.
    b. Six necropsies were conducted and samples were submitted for testing.
    c. Four individuals of two deer species (three black-tailed deer, BTD and one Columbian white-tailed deer, CWTD) at Gresham (BTD – Oxbow Park), Prescott (BTD), McMinnville (BTD) and Clatskanie (CWTD) came back positive for adenovirus hemorrhagic disease (AHD).

Columbian White-Tailed Deer (*Odocoileus virginianus leucurus*) Columbia River Distinct Population Segment Population and Habitat Viability Assessment

List of Acronyms

AHD	Adenovirus hemorrhagic disease
APHIS	Animal and Plant Health Inspection Service
AWV	America's Wildlife Values
BPA	Bonneville Power Administration
BNSF	Burlington Northern Santa Fe
BTD	Black-tailed deer
CLT	Columbia Land Trust
CPSG	Conservation Planning Specialist Group
CTI	Cowlitz Tribe of Indians
CSR	Columbia Stock Ranch
CWD	Chronic Wasting Disease
CWTD	Columbian White-Tailed Deer
DLCD	Department of Land Conservation and Development (Oregon)
DNR	Department of Natural Resources
DOT	Department of Transportation
DPS	Distinct Population Segment
EHD	Epizootic hemorrhagic disease
ES	Ecological Services
ESA	Endangered Species Act
FEMA	Federal Emergency Management Agency
FLIR	Forward looking infrared
GIS	Geographic Information System
HD	Human Dimensions
IDFG	Idaho Fish and Game
IUCN	International Union for the Conservation of Nature
JBH	Julia Butler Hansen National Wildlife Refuge
LC	Lower Columbia
NCASI	National Council for Air and Stream Improvement
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
NWR	National Wildlife Refuge
OAS	Oregon Academy of Science
ODOT	Oregon Department of Transportation
ODFW	Oregon Department of Fish and Wildlife
OHA	Oregon Hunter's Association
OSU	Oregon State University
PESTLE	Political, Economic, Social, Technological, Legal, and Environmental (analysis)
PHVA	Population and Habitat Viability Assessment
PVA	Population Viability Analysis
RNWR	Ridgefield National Wildlife Refuge
SBU	Survival Benefit Unit
SCTI	Species Conservation Toolkit Initiative

SSC	Species Survival Commission
SWAP	State Wildlife Actin Plan
UAF	University of Alaska Fairbanks
UAV	Unmanned Aerial Vehicle
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UW	University of Washington
WDFW	Washington Department of Fish and Wildlife
WSDOT	Washington Department of Transportation
WSU	Washington State University
WTD	White-tailed deer

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Executive Summary

Introduction

The Columbian white-tailed deer (CWTD: *Odocoileus virginianus leucurus*) is restricted in its distribution to the lower Columbia River basin along the Washington – Oregon border, and in Douglas County in southwestern Oregon. The Douglas County population was delisted according to the US Endangered Species Act in 2003, leaving the Columbia River Distinct Population Segment (DPS) as the sole target of conservation management. At present, the Columbia River DPS consists of a series of subpopulations spread out among multiple islands in the Lower Columbia River, with a total population of more than 400 individuals maintained since 1984 (Figure 1).

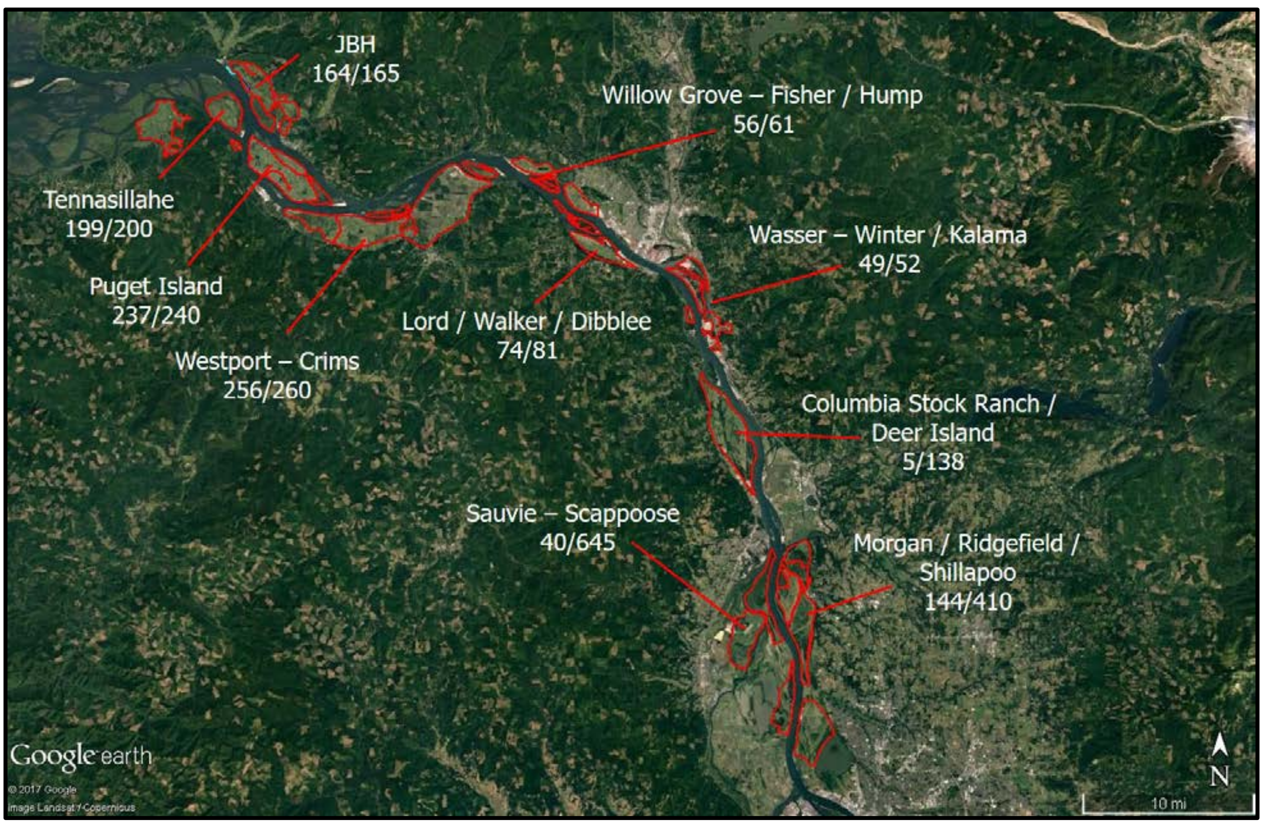

Figure 1. Current distribution of the Columbia River Distinct Population Segment (DPS) of the Columbian white-tailed deer. The first number for each subpopulation denotes the current deer abundance (as of January 2018), and the second number gives the estimated habitat carrying capacity. Graphic courtesy of Paul Meyers, USFWS.

A 5-Year Status Review conducted by the US Fish and Wildlife Service in 2013 recommended the development of a population viability analysis (PVA) for the subspecies DPS as its top priority action. The Review summarized the overall objective of the proposed analysis:

> Given that such a large proportion of CWTD reside on unprotected habitats, consideration should be given to whether the overall population, minimum secure subpopulations, and distribution of the deer within the subpopulations are still adequate to achieve recovery.

The proposed analysis was identified as a potentially important tool to address the following management questions:

1. What number and demographic makeup across the various islands is required for a stable or increasing CWTD population for the next 100 years?
2. Which life history stages are more important determinants of stability of CWTD populations?
3. How do the impacts of limited/fragmented habitat and flooding effect CWTD population extinction risk?
4. What survival for juveniles and adults would be required for stable or increasing CWTD populations (i.e. with or without predator control or reintroduction)?
5. What reintroduction scenarios lead to the most stable or increasing CWTD populations (model these)?

Other benefits to come from a detailed population-level analysis could include:

- Identification of clearer funding objectives and a common understanding of implementation needs for DPS recovery or management;
- An assessment of inefficiencies and successes in how WDFW currently partners with other organizations to implement recovery for CWTD; and
- Shining light on a variety of other challenges to population viability and management, such as low genetic diversity, low female survival, improving reintroduction techniques, limiting human-wildlife conflict, etc.

Therefore, to initiate and inform this effort, the Washington Department of Fish and Wildlife sought the assistance of the Conservation Planning Specialist (CPSG), part of the Species Survival Commission (SSC) of the International Union for Conservation of Nature (IUCN), to conduct a population viability analysis (PVA) workshop with state wildlife management experts from Washington and Oregon Departments of Fish and Wildlife, US Fish and Wildlife Service, and the Cowlitz Tribe. The PVA process was then followed by a Population and Habitat Viability Assessment workshop to assist in long-term conservation planning for the DPS.

The Population Viability Analysis Process

A workshop was convened in December 2017 to bring together species experts and population managers for the purpose of constructing a population viability analysis (PVA) to address challenges to CWTD conservation in the Columbia River DPS. The PVA Technical Team attending this workshop was composed of Federal and state wildlife management agency representatives, as well as specialists in CWTD population biology and genetics. The computer modeling tool known as *Vortex* (Version 10) was used to construct a set of scenarios that simulate the demographic and genetic processes governing wildlife population growth, the threats to long-term population stability, and the potential impacts of management alternatives designed to improve that stability. Model development continued from December 2017 to the convening of the Population and Habitat Viability Assessment workshops held in April and August, 2018.

A simple analysis of data on recent trends in CWTD abundance during the period 1995 – 2005 across the occupied subpopulation units (Puget Island, Tennasillahe Island, Westport / Wallace Island, JBH Mainland Unit) (USFWS 2013) reveals an annual rate of total population decline that approaches 4% over the period when relatively more consistently reliable monitoring methods were employed through time. The beginning of this time interval for analysis was chosen to roughly coincide with the presumed return of the JBH Mainland Unit population to a more sustainable abundance following severe overpopulation of the area, far beyond the habitat's long-term carrying capacity. This PVA, informed by recent threats analysis provided by State and Federal authorities in their recovery plan evaluations (USFWS 2013, Azerrad 2016), identified a suite of threats that are likely contributors to the observed metapopulation decline in recent decades.

A set of model scenarios were developed that described alternative rates of potential future subpopulation growth: low growth, with a long-term mean growth rate $r_s \approx 0.00$; medium growth, with a long-term mean growth rate $r_s \approx 0.02$; and high growth, with a long-term mean growth rate $r_s \approx 0.04$. These scenarios are based on an assumed response to broad threat mitigation activities, primarily in the form of predator (coyote) control that would result in corresponding changes in fawn survival. These model growth rates represent a substantial improvement over the mean metapopulation declines for the Columbia River DPS described above, yet they are also well within the range of growth rates considered feasible for the species. In addition, the scenarios included future threats from increased habitat loss and severe flooding events. These models, while somewhat exploratory in nature given our incomplete understanding of the likelihood and severity of these potential threats, are valuable in their ability to assess various plausible "what-if" scenarios of future conditions in the DPS and the potential impacts of these events.

Detailed study of the model results comprising this risk analysis, and their implications for CWTD conservation, revealed the following key messages:

- The recovery criteria as currently described in the 1983 Recovery Plan do not adequately identify the conditions necessary for long-term demographic or genetic viability of the Columbia River DPS. Statements that extend beyond definitions of population abundance, additionally identifying population growth thresholds and appropriate timeframes over which that growth is observed, would greatly improve the strength of the criteria as a means for assessing the recovery status of the DPS.
- Under a revised set of recovery criteria that incorporate a more informative set of population demographic characteristics, the Columbia River DPS can be considered for recovery with sustained average population growth over a biologically meaningful time period, and with the risk of future habitat loss across the component subpopulations reduced to a minimum acceptable level.
- Managing demographically and genetically robust subpopulations located in the middle of the DPS distribution – here labeled Group B subpopulations – is critical for maintaining connectivity among the chain of subpopulations that comprise the metapopulation. Ideally, this management activity includes an expansion of suitable available habitat in these critical Group B subpopulations in order to further improve their long-term viability.
- New data on population demographics (including mean birth rates, age-specific survival rates, and dispersal rates between subpopulations) through improved monitoring efforts would greatly enhance population management capacity across the DPS.

The models used in the PVA will be made available to Federal and State management authorities, in the hopes that they can be updated in the future with new population data as it becomes available.

The Species Conservation Planning Process

The first Population and Habitat Viability Assessment (PHVA) workshop was conducted 24 – 26 April 2018 in Ridgefield, WA, and was hosted by Washington Department of Fish and Wildlife. The workshop featured thirty participants with expertise in deer population dynamics and habitat assessment, wildlife management on state and federal lands, and endangered species recovery planning and policy development. After a presentation on species status and current recovery actions, there was a detailed presentation summarizing the population viability analysis (PVA) process that preceded the conservation planning process. Following these presentations, the participants evaluated the existing USFWS 5-Year Review of the Federal Recovery Plan. The purpose of the evaluation was to assess the extent of completion of each of the Review's recommendations, to consider revisions to recommendations yet to be completed, and to propose additional recommendations not currently in the Review.

Following this Review evaluation, the participant body was divided into two working groups: Habitat Management and Population Management. Each group's first task was to discuss the Review evaluation in a bit more detail from their specific topical perspective to provide more info to the future planning process. Each working group then conducted a PESTLE analysis, which is a tool for helping organizations and projects (where multiple organizations might be working together to achieve a common goal) to review a range of external forces – Political, Economic, Social, Technological, Legal, and Environmental – which could be now or in the future impacting on their work. By analyzing the above factors, organizations and project teams can begin to capture an understanding of the current, historic or future systemic changes which may impact on their work, either positively (presenting an opportunity), or negatively (presenting a threat).

With this PESTLE analysis in hand, each group then identified specific challenges to effective CWTD conservation of both populations and their habitat. This specification of challenges then facilitates the creation of longer-term (2-5 year) conservation goals, along with shorter-term detailed conservation actions that will collectively achieve the specified goals. These actions are detailed descriptions of measurable activities, with the identification of responsible parties, reasonable timelines and primary obstacles to completing the action. Detailed specification of conservation action will improve the likelihood of positive change for conservation of the species in the wild. The PVA is an important resource at this stage, where participants can target aspects of species biology and life-history for additional research and management, and can make more informed decisions about specific management activities that predicted to improve long-term viability of the DPS. The goals and actions developed by this group can provide the basis for an effective conservation strategy for this DPS in the context of continued species recovery planning.

A second workshop was held in Ridgefield, WA on 1 August 2018 with a slightly smaller subset of the original participants. This follow-up meeting was designed to review the actions developed at the original PHVA workshop, and to provide additional detail on the action specifications. The group then undertook a prioritization process where actions across both Habitat and Population working groups were prioritized on the basis of their importance for contributing to long-term viability of the Columbia River DPS. The process generated a set of "top-tier" and "second-tier" actions to be highlighted for further activity. This synthesis of the full suite of actions provides a type of "road map" for effective conservation of the Columbian white-tailed deer in this region of its distribution.

Summary of Workshop Findings

Population Working Group

The working group derived a set of issues/challenges to CWTD conservation and, with the preparatory work on threats and opportunities to effective conservation in hand, developed the following conservation goals:

1. In order to maintain a stable or increasing DPS population, increase doe survival and fawn recruitment.
2. Reintroduce CWTD to suitable habitat within the DPS to increase connectivity, distribution, and abundance in the DPS.
3. Conduct consistent monitoring of the total DPS regularly to establish population trends while exploring alternative methods of population monitoring for total population counts, doe:fawn, and BTD:CWTD ratios.
4. Obtain current demographic data to better inform management actions.
5. Evaluate the genetic structure and variability of the Douglas County DPS, lower Columbia River DPS, and Northeast Oregon populations in order to answer questions related to taxonomy, hybridization with black-tailed deer, and inbreeding, and to guide translocation decisions.
6. To mitigate potential future risks to population viability, create a response plan for emerging diseases and invasive pathogens.

A number of detailed conservation actions were designed to achieve these goals, focusing largely on expanding our knowledge of the species' biology in the wild. Completing these actions will be instrumental in addressing Recommendations 15, 16 and 19 from the 5-Year Review that have not yet been fully completed. With this expanded knowledge, the mechanics of effective management planning, informed in part by the PVA, can proceed with greater clarity and expediency.

Habitat Working Group

In the same vein as the Population group, the Habitat working group derived the following conservation goals:

1. Acquire or gain access to habitat for CWTD that prioritizes connectivity and upland habitats for both translocation and acquisition efforts.
2. Conduct habitat restoration and enhancement efforts on currently occupied CWTD habitat, on potential future CWTD translocation/acquisition areas, and on candidate corridor habitats that could serve as linkages among sites. Use best available science and adaptive management to inform restoration and enhancement efforts.
3. Utilize best available science to monitor current and likely future threats to CWTD to inform the securing and management of their habitat.

Again, detailed conservation actions were identified to achieve these goals. The group recognized the importance of focusing on effective management of habitat in those Group B subpopulations – Willow Grove – Fisher / Hump, Lord / Walker / Dibblee, and Wasser – Winter / Kalama – that can play a vital role in maintaining effective demographic connectivity across the larger subpopulations that make up the full metapopulation. Completing these actions will be instrumental in addressing Recommendations 2, 3, 4 and 10 from the 5-Year Review that have not yet been fully completed.

Follow-Up Workshop Activities

As a result of the follow-up workshop, the following "top-tier" actions were identified. Each action is referenced to the working group that created it, and the numerical designations for each make a reference to the conservation goal associated with each action; in other words, Action 2.1 with the "Population" designation refers to Action 1 for Population Goal 2. The score used to prioritize the actions was obtained through a standard paired-ranking procedure used by each participant in the follow-up workshop. These actions are also highlighted with green text boxes in the report text that follows.

Population Action 2.1	Translocate an appropriate number of deer from Tennasillahe to Columbia Stock Ranch (near Deer Island) starting in 2018, and monitor survival and movement of translocated deer with radio-telemetry for the first two years and continue yearly with FLIR, when possible. [Score: 111]
Population Action 3.1	Complete FLIR monitoring of the total DPS within a two year period. [Score: 88]
Population Action 3.4	Continue ground monitoring of doe:fawn to estimate fawn recruitment and road counts and camera surveys to obtain BT:CWTD ratios that are used as a correction factor to FLIR counts. [Score: 82]
Habitat Action 2.1	Re-establish deciduous forested habitats (including expanding riparian vegetation, tree and shrub planting, water manipulation) available with the DPS, and also identify areas outside the DPS where feasible. [Score: 78]
Habitat Action 1.2	Confirm availability of priority parcels of land through engagement with parcel landowners [Score: 71]
Population Action 1.3	Improve fawning habitat by: i. Improving habitat connectivity ii. Using conservation tools to work with private lands (including Safe Harbor Agreements, Habitat Conservation Plans, and Partners projects) iii. Alter cattle grazing patterns [Score: 71]
Population Action 2.4	Continue to identify additional translocation opportunities. [Score: 71]
Population Action 1.2	Because survival and fecundity are related to body condition, improve forage and browse quality and abundance. [Score: 61]
Population Action 2.2	Enhance recipient site through predator control prior to translocation, if warranted. [Score: 52]
Population Action 1.1	Continue predator removal/control using action thresholds identified in Refuge management plans at JBH Mainland, Tennasillahe Island, and Ridgefield. [Score: 50]
Habitat Action 1.5	Prioritize sites to restore CWTD to their historic habitat/range and assure their viability, including identifying adjacent upland habitats to the existing DPS. [Score: 44]
Population Action 2.5	Evaluate and improve translocation methodology. [Score: 34]
Population Action 5.3	Genetic sampling during future translocations to evaluate hybridization. [Score: 29]
Population Action 6.1	Collaborate with state DFW and departments of agriculture to ensure that CWTD are included in emerging disease response plans. [Score: 11]

Additionally, the following "second-tier" actions were identified:

Habitat Action 2.2	Forage Enhancements; e.g.,: Treat invasive plants (e.g., canary grass); Manage grazing (e.g., rotational experiments); Create enhanced forage areas (deer specific?); Fertilizer; Mowing/haying areas; Prescribed burns; Increase presence of pollinators; Implement results identified from "Analysis of habitat to identify insufficiencies" (see Planning) [Score: 30]
Habitat Action 1.4	Model impact(s) of the loss of Tennasillahe population and possible gain of CWTD elsewhere. [Score: 29]
Population Action 3.2	Work with biometrician to establish monitoring intervals to evaluate population trends across the DPS. [Score: 27]
Population Action 1.7	Body condition study [Score: 26]
Habitat Action 1.3	Couple connectivity analysis and identified CWTD habitat quality map. [Score: 26]
Habitat Action 1.6	Incorporate information from the PVA in the decision-making process for the Tennasillahe island restoration project. [Score: 25]
Population Action 5.4	Develop a management plan for hybrid animals. [Score: 24]
Population Action 5.2	Resample Ridgefield deer and compare to data collected in 2014-2015 in order to evaluate if hybridization has occurred. [Score: 20]
Habitat Action 4.1	Utilise FEMA to inform flood threat analyses for the species. [Score: 20]
Population Action 3.3	Explore the use of UAVs in FLIR monitoring. [Score: 18]
Population Action 1.6	Collaborate with the DOT and rail lines to investigate methods to quantify and mitigate train and vehicle strikes in high risk areas. [Score: 14]
Habitat Action 1.7	Revise and establish inter-agency communication channels to ensure effective communication of future decisions (including land acquisitions) and where inter-agency input required (e.g. within Inter-Agency bi-monthly calls and face-to-face meetings. Include Columbia Land Trust to bi-monthly calls) [Score: 11]
Population Action 1.5	Add selenium on managed lands in order to increase doe survival. [Score: 7]

Taken together, these conservation goals and actions comprise the proactive component of a "living document" that is designed to guide future conservation planning for the Columbian white-tailed deer, with periodic revisions as new data, information and insights become available. This material can form the basis of an Action Plan for the subspecies that features a more detailed and overarching implementation plan to coordinate multiple, mutually supporting activities to improve the long-term prospects for the species in the wild.

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Population Viability Analysis for the Columbian White-Tailed Deer (*Odocoileus virginianus leucurus*)

A Metapopulation Modeling Approach to Assist Conservation Planning for the Columbia River DPS

Report prepared by

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3 July 2019

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Population Viability Analysis for the Columbian White-Tailed Deer (*Odocoileus virginianus leucurus*)

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A Metapopulation Modeling Approach to Assist Conservation Planning for the Columbia River DPS

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IUCN SSC Conservation Planning Specialist Group

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Introduction

This document describes the demographic and genetic simulation model developed for population viability analysis (PVA) of the Columbia River Distinct Population Segment (DPS) of the Columbian white-tailed deer (*Odocoileus virginianus leucurus*). This analysis is intended to assist Federal and state wildlife managers in developing management strategies designed to increase the prospects for long-term viability of the subspecies throughout the range of the DPS. The model features a metapopulation structure that allows for detailed analysis of individual subpopulations and their demographic interactions along the length of the Columbia River that defines the population segment.

Population viability analysis (PVA) can be an extremely useful tool for investigating current and future demographic dynamics of the CWTD metapopulation. The need for and consequences of alternative management strategies can be modeled to suggest which practices may be the most effective in managing this metapopulation.

The modeling tool used in this analysis is the stochastic individual-based software package *Vortex* (Lacy and Pollak 2017; Lacy et al. 2014). The *Vortex* package is a flexible simulation of the effects of a number of different natural and human-mediated forces – some, by definition, acting unpredictably from year to year – on the health and integrity of wildlife populations. *Vortex* models population dynamics as discrete sequential events (e.g., births, deaths, sex ratios among offspring, catastrophes, etc.) that occur according to defined probabilities. The probabilities of events are modeled as constants or random variables that follow specified distributions. The package simulates a population by recreating the essential series of events that describe the typical life cycles of sexually reproducing organisms. *Vortex* is used around the world by government agencies and independent researchers as a tool to create scientifically robust conservation strategies for endangered species. While no software application can be guaranteed to be completely error-free, the wide use of *Vortex* means that it is tested to a much greater extent than similar types of models that are created for specific projects. Simulations using this tool have been shown to produce predicted population abundance trajectories that are consistent with monitored wildlife populations (Brook et al. 2000a) and that are concordant with other similar software platforms (Brook et al. 2000b). *Vortex* is distributed freely and can be obtained online at www.vortex10.org/vortex10.aspx.

PVA methodologies such as the *Vortex* system are not intended to give absolute and accurate "answers" for what the future will bring for a given wildlife species or population. This limitation arises simply from two fundamental facts about the natural world: it is inherently unpredictable in its detailed behavior; and we will never fully understand its precise mechanics. Consequently, many researchers have cautioned against the exclusive use of absolute results from a PVA in order to promote specific management actions for threatened populations (e.g., Ludwig 1999; Beissinger and McCullough 2002; Reed et al. 2002; Ellner et al. 2002; Lotts et al. 2004). Instead, the true value of an analysis of this type lies in the assembly and critical analysis of the available information on the species and its ecology, and in the ability to compare the quantitative metrics of population performance that emerge from a suite of simulations, with each simulation representing a specific scenario and its inherent assumptions about the available data and a proposed method of population and/or landscape management. Interpretation of this type of output depends strongly upon our knowledge of Columbian white-tailed deer biology, the environmental conditions affecting the species, and possible future changes in these conditions. Under thoughtful and appropriate interpretation, results from PVA efforts can be an invaluable aid when deriving meaningful and justifiable endangered species recovery criteria (Doak et al. 2015).

Guidance for PVA Model Development

A recent 5-Year Status Review conducted by the US Fish and Wildlife Service (USFWS 2013) recommended the development of a population viability analysis (PVA) for the Columbia River DPS as its top priority action. This document summarized the overall objective of the proposed analysis:

> Given that such a large proportion of CWTD reside on unprotected habitats, consideration should be given to whether the overall population, minimum secure subpopulations, and distribution of the deer within the subpopulations are still adequate to achieve recovery.

The proposed analysis can be an important tool to address the following management questions:

- What number and demographic makeup across the various islands is required for a stable or increasing CWTD population for the next 100 years?
- Which life history stages are important determinants of CWTD population stability?
- How do the impacts of limited and fragmented habitat and flooding affect CWTD population extinction risk?
- What survival for juveniles and adults would be required for stable or increasing CWTD populations (i.e. with or without predator control or reintroduction)?
- What reintroduction scenarios lead to the most stable or increasing CWTD populations?

A workshop was convened in December 2017 to bring together species experts and population managers for the purpose of constructing a PVA model to address the above challenges. The PVA Technical Team attending this workshop was composed of Federal and state wildlife management agency representatives, as well as specialists in CWTD population biology and genetics (Table 1). Team members have been engaged in ongoing model development since the initial workshop. The analysis is designed to serve as an important science-based focal point for discussion among a larger body of wildlife managers and agency decision-makers during the Population and Habitat Viability Assessment workshop held in April 2018.

Table 1. Composition of the CWTD PVA Technical Team.

Name	Affiliation
Jeff Azerrad	WA Department of Fish and Wildlife
Stephanie Bergh	WA Department of Fish and Wildlife
Herman Biederbeck	OR Department of Fish and Wildlife
Alex Chmielewski	US Fish and Wildlife Service
Amy Darr	OR Department of Fish and Wildlife
Sandra Jonker	WA Department of Fish and Wildlife
Paul Meyers	US Fish and Wildlife Service
Phil Miller	IUCN Conservation Planning Specialist Group
Toni Piaggio	APHIS / US Department of Agriculture
Jennifer Siani	US Fish and Wildlife Service
Winston Smith	University of Alaska - Fairbanks
Nicholle Stephens	WA Department of Fish and Wildlife
Erik White	Cowlitz Tribe

A number of information gaps exist in our detailed understanding of CWTD population demographics. In light of this fact, this PVA is not designed to accurately describe the current demographic and genetic characteristics of individual subpopulations currently comprising the Columbia River DPS metapopulation. Furthermore, it is not possible to confidently predict the specific fate of the DPS at a given time in the future under a defined set of conditions, e.g., no change in current management activities across the component subpopulations. Rather, and in keeping with the questions listed above, this analysis is designed to give guidance on the demographic conditions expected to confer a given level of population stability or growth under an assumed set of future ecological conditions.

Input Data for PVA Simulations

Metapopulation Specification

With the exception of a few special cases, all the models discussed in this report will feature a metapopulation structure in which component subpopulations, each with their own demographic characteristics, may be linked to one or more of their nearest neighbors through the occasional dispersal of individuals through time. Specifically, our metapopulation is comprised of ten distinct subpopulations (Figure 1; Table 2) that are defined primarily on the basis of (i) acknowledged limited exchange of individuals across subpopulation boundaries; (ii) land tenure/jurisdiction; and (iii) a documented history of natural dispersal within identified subpopulation boundaries following translocation events.

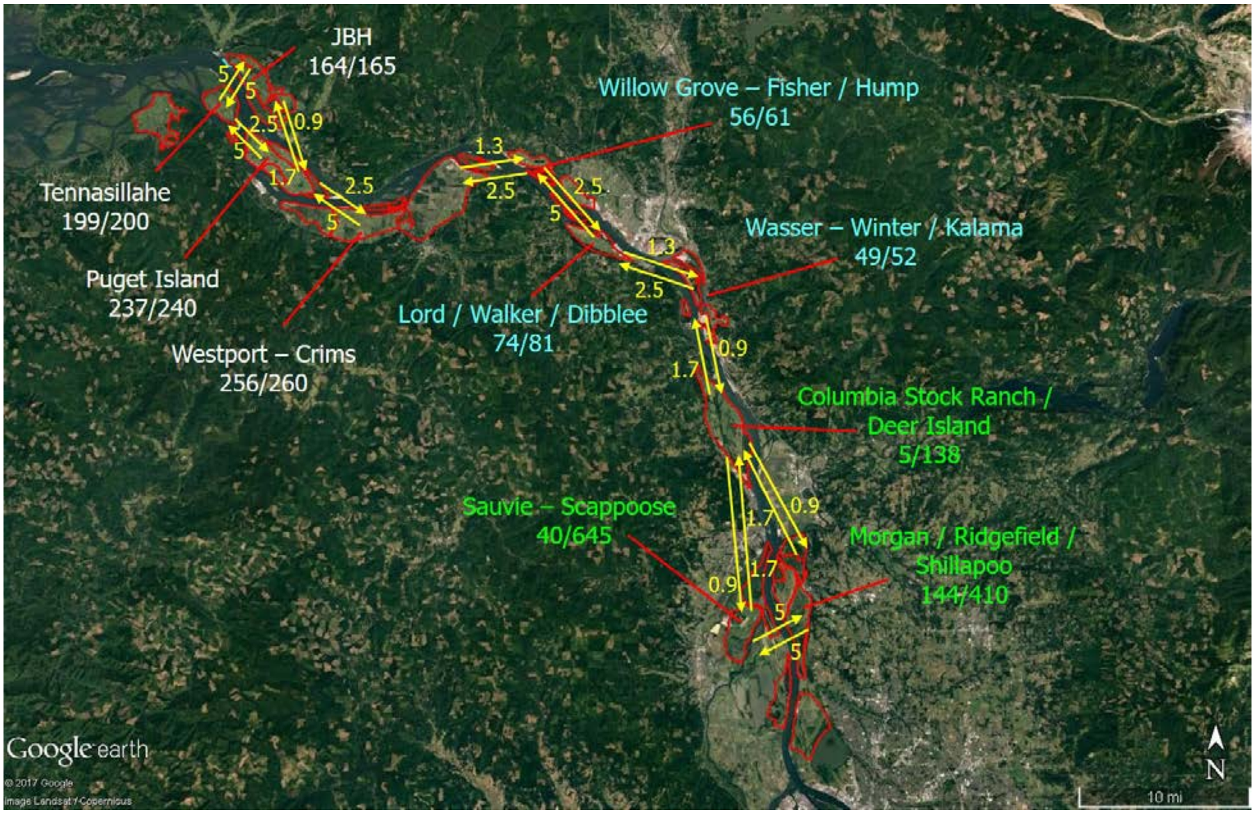


Figure 1. Subpopulation designations for Columbian white-tailed deer across the Columbia River DPS. Color codes for subpopulation designations: white, Group A; cyan, Group B; green; Group C. For each subpopulation, the first numerical value gives the estimated deer abundance (Age-1 and older) as of January 2018, while the second value gives the estimated management-based carrying capacity. Yellow arrows depict directional annual dispersal probabilities (expressed as percentages of candidate age-sex classes) between subpopulations. Primary data source and map courtesy of: P. Meyers, USFWS.

Table 2. Component habitats for each of the subpopulations defining the Columbia River DPS metapopulation.

Subpopulation Designation	Habitat Components
Julia Butler Hanson NWR (JBH)	JBH Mainland NWR; Price Island; Hunting Island; CLT Land; Elochoman Valley; Town of Cathlamet and surrounding areas
Tennasillahe	Tennasillahe Island
Puget Island	Puget Island; Little Island; Whites Island; Bradwood
Westport – Crims	Westport/Karamanos; Marshland; Clatskanie; Crims Island
Willow Grove – Fisher / Hump	Willow Grove; Fisher / Hump Islands; Longview Industrial
Lord / Walker / Dibblee	Lord Island; Walker Island; Dibblee
Wasser – Winter / Kalama	Wasser – Winter; Cottonwood; Kalama
Columbia Stock Ranch / Deer Island (CSR/DI)	Columbia Stock Ranch; Deer Island (private land)
Sauvie – Scappoose	Northern Sauvie; Southern Sauvie; Scappoose
Morgan / Ridgefield / Shillapoo	Morgan; Ridgefield NWR; Shillapoo plus neighboring CLT land; private land near Shillapoo

The current abundance (Age-1 deer and older) for each subpopulation was estimated from FLIR (forward-looking infrared) survey data maintained by the US Fish and Wildlife Service. Abundance estimates for specific habitat components may not have been obtained in the same year, but were nevertheless combined to generate a best estimate of overall subpopulation abundance. For most subpopulation components, the most recent year of abundance estimation was 2016, with a small proportion of estimates dating back to 2014 or 2010. The abundance of each simulated subpopulation was initialized at timestep *t*=0 by apportioning individuals among age and sex classes according to an approximate stable age distribution that is defined by the demographic rates assigned to each subpopulation (see following sections on model input).

The carrying capacity for each subpopulation is a fixed value (unless specified otherwise) and acts as a ceiling form of density-dependent survival across all age classes. This parameter was calculated based on knowledge of the amount of suitable white-tailed deer habitat in each of the subpopulation habitat components, and on an estimate of the expected density of deer across a range of land tenure types:

Public land, managed for deer	Expected density = 35 – 40 deer/mi2
Public land, not managed for deer	Expected density = 10 – 20 deer/mi2
Private land, not managed for deer	Expected density = 10 – 30 deer/mi2

Habitat components were scored for their land tenure and assigned a specific expected deer density, with the total carrying capacity for a subpopulation estimated as the sum of the capacity of each habitat component. In situations where the estimated carrying capacity was smaller than the current subpopulation abundance estimate, the carrying capacity estimate was increased to be roughly equivalent to the current abundance, in effect assuming that the subpopulation is currently at its ecological carrying capacity.

Inspecting the details of Figure 1 suggests that, for the purpose of this PVA, the subpopulations can be broadly organized into three distinct groups, organized geographically from downstream (northwest) to upstream (southeast) and, secondarily, based on their broad abundance characteristics:

- Group A: Farthest downstream; larger subpopulations, at or near their estimated carrying capacities and therefore with restricted opportunities for future growth.
  JBH; Tennasillahe; Puget Island; Westport – Crims
- Group B: Middle section; smaller subpopulations, also at or near their estimated carrying capacities and similarly restricted in their opportunities for growth.
  Willow Grove – Fisher / Hump; Lord / Walker / Dibblee; Wasser – Winter / Kalama
- Group C: Farthest upstream; typically smaller subpopulations, far below their estimated carrying capacities and therefore with ample opportunities for future growth.
  Columbia Stock Ranch / Deer Island; Sauvie – Scappoose; Morgan / Ridgefield / Shillapoo

Very little is known about the quantitative extent of dispersal among CWTD subpopulations in the Columbia River DPS (Gavin et al. 1984). It is therefore necessary to rely on more general studies of dispersal in white-tailed deer, where it is recognized that young males comprise the large majority of dispersing individuals (e.g., Smith 1991; Nelson and Mech 1992). Based on this and other corroborating evidence, we assumed that dispersal between subpopulations can occur among Age-1 and Age-2 individuals, and that males of that cohort will make up about 80% of the dispersing individuals. Furthermore, we assume that 90% of the dispersing individuals will successfully reach their destination, corresponding to 10% average mortality among dispersers in any given year.

Our PVA model defines dispersal rate as the probability that an individual of the qualifying age and sex in the source population will disperse to a neighboring subpopulation in a given year of the simulation.

Figure 2 indicates the dispersal rates among subpopulations in the Columbia River DPS metapopulation. The rates derived in this analysis were informed by a habitat connectivity analysis recently performed by the Washington State Department of Transportation (WSDOT 2016) that focused on the northern (downstream) portion of the extent of the DPS. Note that the dispersal dynamics generally follow a “stepping stone” model, where dispersal occurs only between nearest-neighbor subpopulations across the geographic length of the metapopulation. For example, the JBH subpopulation is demographically linked to the Tennasillahe and Puget Island subpopulations, but does not exchange individuals with subpopulations that are farther upstream, e.g., Westport-Crims. Additionally, it is evident from inspecting Figure 2 that dispersal rates among subpopulation pairs are typically asymmetric. Specifically, we assume that the upstream rate of dispersal between two subpopulations – that is, dispersal from a more northwesterly subpopulation to a more southeasterly subpopulation – is generally lower than the downstream dispersal rate between those same two subpopulations. This assumption is based on the knowledge that nearly all the dispersal occurring across this metapopulation requires deer to swim from one subpopulation to another. Among those subpopulations pairs that are arranged spatially in a manner that would likely not require net upstream or downstream movement – for example, JBH and Tennasillahe – we assume symmetric dispersal probabilities.

These dispersal dynamics are likely to be simplistic, as the specific landscape structure and extent of urban vs. rural habitats across the intervening spaces will almost surely influence the true dispersal mechanics. However, in the absence of detailed data providing evidence of a more complex dispersal dynamic, we are better served by adopting a more simplified approach to this component of the analysis.

	JBH	Tennasillahe	Puget Island	Westport - Crims	Willow Grove - Fisher / Hump	Lord / Walker / Diblee	Wasser - Winter / Kalama	Columbia Stock Ranch / Deer Island	Sauvie - Scappoose	Morgan / Ridgefield / Shillapoo
JBH		5	0.9	0	0	0	0	0	0	0
Tennasillahe	5		2.5	0	0	0	0	0	0	0
Puget Island	1.7	5		2.5	0	0	0	0	0	0
Westport - Crims	0	0	5		1.3	0	0	0	0	0
Willow Grove - Fisher / Hump	0	0	0	2.5		2.5	0	0	0	0
Lord / Walker / Diblee	0	0	0	0	5		1.3	0	0	0
Wasser - Winter / Kalama	0	0	0	0	0	2.5		0.9	0	0
Columbia Stock Ranch / Deer Island	0	0	0	0	0	0	1.7		0.9	0.9
Sauvie - Scappoose	0	0	0	0	0	0	0	1.7		5
Morgan / Ridgefield / Shillapoo	0	0	0	0	0	0	0	1.7	5	

Figure 2. Matrix of dispersal rates among subpopulations making up the Columbia River DPS metapopulation. Values in each cell give the % probability that a qualifying individual will disperse from the source population (row heading) to the recipient population (column heading) in a given year of a simulation. Rates below the diagonal in green dells denote downstream dispersal, while rates above the diagonal in tan cells denote upstream dispersal. See accompanying text for more information on the metapopulation dispersal dynamics included in the model.

Threats to Subpopulation Viability

Analysis of historic data included in the USFWS 5-Year Review (USFWS 2013) indicates that the Columbia River DPS metapopulation declined in abundance during the period of 1995 – 2005 by an average annual rate of approximately 4%, excluding the small populations inhabiting the Upper Estuary Islands that were established in 1999. This decline is no doubt caused in large part by the combined action of a suite of threats to deer reproduction and/or survival. During the December 2017 PVA workshop, participants identified a series of threats to CWTD subpopulation viability that could be considered for exploration in the current PVA (Figure 3). This threat analysis is not meant to replace similar types of analyses discussed in more detail in the recent status reviews conducted by Federal (USFWS 2013) and state (Azerrad 2016) authorities, but is instead meant to augment the information currently available to wildlife managers. For more information on the broad array of identified threats affecting the DPS as a whole, the reader is referred to the status reviews cited above. In particular, we recognize that important factors such as disease and coyote predation are identified threats across all subpopulations and are therefore not specifically highlighted in this metapopulation-level analysis.

A notable feature of the workshop's threat analysis is the preponderance of threats targeting future habitat availability (carrying capacity). The various threats targeting habitat can be assessed in a very broad way in a PVA framework by evaluating the impact of reduced habitat availability over time, which would be reflected in a reduced habitat carrying capacity in the future. Unfortunately, we don't have detailed data on the functional relationships linking a given threatening process, such as increased agricultural intensity or reed canary grass encroachment, and the quantitative ecological impact on CWTD habitat availability. Instead, we must generate simplified models featuring a gradual reduction in habitat carrying capacity over time that is thought to be broadly representative of the impact of the various threats to CWTD habitat.

Threat	Target of Threat	JBH	Tennasillahee	Puget Island	Westport - Crims	Willow Grove - Fisher / Hump	Lord / Walker / Diblee	Wasser - Winter / Kalama	CSR / Deer Island	Sauvie - Scappoose	Morgan / Ridgefield / Shillapoo
		Low	Low	Low	Med	Low	Med	Med	High	High	High
		Public	Public	Private	Private	Private	Mostly Private	Mostly Private	Private	50% Public	75% Public
Rising ground water from sea level rise	Carrying capacity	red	red	red	red	red	red	red	red	red	red
Limited opportunity of expansion beyond current subpop. range	Carrying capacity	red	red	red	red	red	red	red	red	red	yellow
Increased agricultural intensity	Carrying capacity	green	green	red	red	red	red	green	red	red	green
Invasive species (includes reed canary grass, etc.)	Carrying capacity	red	red	green	yellow	green	yellow	red	yellow	yellow	yellow
Land use changes/urbanization	Carrying capacity	green	green	yellow	yellow	yellow	yellow	red	yellow	yellow	red
Proposed salmon restoration	Carrying capacity	green	red	green	yellow	green	green	green	yellow	yellow	red
Periodic flooding (typically in autumn or winter)	Autumn: fawn production. Summer: fawn survival impacted greater	red	red	red	yellow	red	yellow	red	yellow	yellow	yellow
Vehicle collisions	Survival (yearlings, translocated animals)	yellow	green	yellow	yellow	green	green	red	yellow	red	yellow
Poaching	Survival	green	green	green	yellow	green	green	green	green	green	green

Figure 3. Threats to Columbian white-tailed deer subpopulations, as identified in the December 2017 PVA workshop. Threats to habitat (upper section) and individuals (lower section) are roughly prioritized on the basis of threat intensity across the Columbia River DPS subpopulations, given by assignment of high (red), medium (yellow) or low (green) threat levels across the subpopulations. Below the subpopulation labels are their estimated black-tailed deer densities and land tenure types. See accompanying text for more information on metapopulation characteristics and demographic data included in the model.

Reproductive Parameters

Breeding system: White-tailed deer display a typical polygynous breeding system, where a single male may breed with multiple females.

Age of first reproduction: “Reproduction” is defined here as the age for an adult at which the first fawns are born. While females will first become pregnant as yearlings, they will be two years old when their first fawns are born in June. In a similar manner, males will be two years of age when fawns from their first breeding events are born. We also assume that all adult males are in the pool of capable breeders in any given year; in other words, we are not excluding certain males from breeding opportunities based on factors such as social standing. This has little demographic consequence in our models but may influence population genetic structure and, by extension, the level of inbreeding within a given subpopulation.

Maximum breeding age / longevity: In our demographic specification of white-tailed deer breeding biology, adults remain capable of producing fawns throughout their adult lifespan, i.e., reproductive senescence is not a feature of our models. We assume that deer will not live beyond 15 years of age, with only a small probability of reaching that age based on the annual mortality rates used as model input (see below).

Percentage of adult females breeding in a given year: While specific data on annual pregnancy rates in this DPS are not available, there are ample data from other white-tailed deer populations to provide a basis for estimating this parameter. Pregnancy rates among breeding-age females often exceed 90% (e.g. Dusek et al. 1989), with yearlings producing fawns at a lower rate than older females. We assumed that, in an average year, 75% of yearling females breed and give birth the following year as 2-year-olds, and that 95% of older females (Age-2+) breed and begin birthing fawns as 3-year-olds. Furthermore, we assume that adult females will continue to breed at the stated rate throughout their adult lifespan, as has been observed and reported in other studies of white-tailed deer (e.g., DelGiudice et al. 2007).

Fawn production: Younger does (Age-2) typically give birth to a single fawn, while older does typically produce twins with some females giving birth to triplets. Specifically, we assumed that 90% of Age-2 breeding females produce a single fawn and 10% produce twins. Among older breeding females (Age-3+), 93% produce twins and 7% produce triplets. Average annual fawn production among breeding females is therefore 1.1 fawns per Age-2 female and 2.07 fawns per Age-3+ female. We assume a mean 50:50 sex ratio among fawns that produced in a given year.

Annual environmental variability in reproduction: Expected mean reproductive rates will vary from year to year in response to variability in external environmental fluctuations. This process is simulated by specifying a standard deviation around the mean rate. The mean and variance for parameters defining reproductive success follow binomial distributions. We set the environmental variation (standard deviation) for the annual probability of breeding at 0.05, meaning that the probability of an Age-2 female producing a fawn is expected to vary across years from approximately 65% to 85% (i.e., mean ± 2SD) and that for an Age-3+ female varies from 90% to 100%.

Density-dependent reproduction: White-tailed females may produce fewer fawns at higher population densities through restricted forage availability (e.g., Woolf and Harder 1979). While acknowledging this observation, we considered the mortality of fawns to be a more realistic target of density effects on CWTD populations and therefore chose to structure our demographic model to impose this density dependence on fawn mortality (see below).

Mortality Parameters

Fawn (Age-0) mortality: Direct estimates of annual fawn mortality for CWTD in the Columbia River DPS are not available, as the primary metric used by population managers to assess fecundity is fawn:doe ratios measured in late autumn / early winter. Based on the reproductive parameters discussed above and on measured fawn:doe ratios for the five downstream subpopulations (JBH through Lord / Walker / Dibblee) since the mid-1990s (2003 for Willow Grove – Fisher / Hump and Lord / Walker / Dibblee), PVA Technical Team members back-calculated fawn survival values to be consistent with the field estimates of fawn:doe ratios. The mean survival rate emerging from this analysis is 22.7% (mean mortality rate = 77.3%).

We assume that fawn mortality is density dependent, with higher mortality rates occurring as the subpopulation approaches the habitat carrying capacity. Given that these subpopulations are at an abundance that is likely near their ecological capacity, we may take the above mean mortality rate estimate as an approximate upper bound. Additional work was done in the model to adjust fawn mortality rates in order to generate a range of intended population growth rates for detailed analysis. This work yielded an annual mean fawn mortality profile of 67% at low density, increasing to 83% at high density (Figure 4), that was consistent with a reference mean stochastic population growth rate $r_s \approx 0.0$. Note that this reference growth rate describes a simulation population this is considered to be isolated from other nearby deer populations and has an abundance that is at or near its ecological carrying capacity. Similar fawn mortality profiles were created for moderate population growth ($r_s \approx 0.02$: 60% mortality at low density / 80% at high density) and high population growth ($r_s \approx 0.04$: 55% mortality at low density / 75% at high density) scenarios. These higher overall CWTD subpopulation growth scenarios, corresponding to an assumed reduction in mean annual fawn mortality rates, may be thought of as simulating specific management actions targeting primary factors contributing to fawn mortality, most notably coyote predation.

Fawn mortality is considered to be equal across both males and females. Furthermore, we specified annual environmental variability in mean fawn mortality as ±10%, which will shift the density-dependence relationship up or down across the range of population densities experienced in a given simulation.

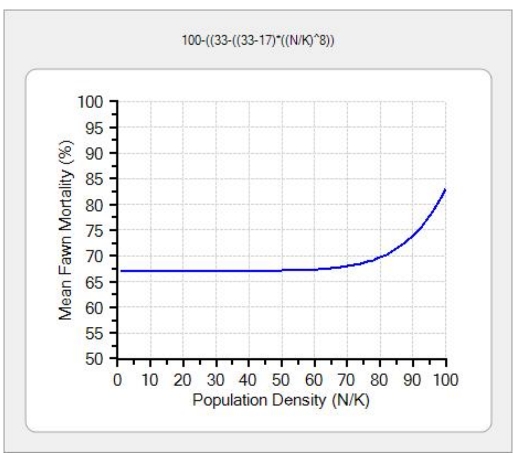


Figure 4. Representative density-dependent fawn mortality function. See accompanying text for additional information on model parameter specification.

Subadult (Age-1) mortality: Beginning at this age class, we assume that male mortality rates are higher than those for females, in keeping with observations of buck:doe ratios in CWTD and other white-tailed deer populations of about 35:100 (e.g., Gavin 1984). Based on these observations, and in keeping with our desire to calibrate mortality rates to generate a target population growth rates of approximately $r_s \approx 0.00$, we set the subadult female annual mean mortality at 14±5% and the subadult male mortality rate at 35±5%.

Adult (Age-2+) mortality: We assume that adult mortality rates for both females and males are equal to the subadult rates, i.e., 14±5% for females and 35±5% for males. These rates are quite similar to those reported for other deer populations (e.g., mule deer in the Rockies: Unsworth et al. 1999; white-tailed deer in South Carolina: Kilgo et al. 2016) and they result in buck:doe ratios that are consistent with relevant literature (e.g., Gavin et al. 1984). When scenarios featuring higher rates of population growth ($r_s = 0.04$) were constructed, adult female and male mortality rates were reduced slightly to 13±5% and 33±5%, respectively.

“Catastrophic” Event

Our demographic model also includes an event with a low frequency (annual probability of occurrence) but with a relatively significant impact on the population that is considered separately from typical annual mortality. Specifically, we include a flooding event that stands apart from what may be considered a more typical annual high-water event. These more typical events are conceptually pooled with other factors that contribute to inter-annual variability in mortality described in the “Mortality Parameters” section above.

Our “catastrophe” flood event, considered separately from more typical annual variability in mortality rates, occurs once every 30-35 years on average, with an annual probability of occurrence of 0.03. When the event is triggered in the simulation, the impact is manifest in a 30% decline in survival across all age classes during the year the catastrophe is deemed to have occurred. In subsequent years – unless the stochastic event occurs again – the survival rates return to their normal values, with density-dependent fawn mortality being applied based on population density following the flooding event.

The precise demographic impact of flood across the Columbia River DPS is not known. Three flooding events are known to have occurred in the area since 1996, but their true demographic impact on local CWTD subpopulations in unknown (USFWS 2013). In light of this information, we may be underestimating the frequency of this type of event; however, lacking data on the impacts of the events, it is unclear if we are misrepresenting the long-term threat posed by periodic flooding.

Inbreeding Depression

Another factor that can potentially impact viability in wildlife populations is the extent of inbreeding depression as a modifier of age-specific survival. Specifically, we include a model of inbreeding depression in our PVA that impacts offspring (fawn) survival, as is typical for many demographic analyses of endangered species (O’Grady et al. 2006). The relationship between the level of inbreeding that characterizes a given mating event involving related individuals (defined by the inbreeding coefficient, F) and the survival of the resulting offspring is given by:

$$S = S_0 e^{-bF}$$

where S is the survival rate of inbred offspring, S_0 is the survival rate of non-inbred offspring, F is the inbreeding coefficient of the offspring, and b is the average number of “lethal equivalents” per haploid genome in the species or population of interest. The value of lethal equivalents is therefore a convenient way to express the strength of inbreeding depression, and can be used to directly compare impacts of inbreeding across populations of the same species or across species.

The number of lethal equivalents in a population of interest is usually estimated in laboratory populations or for small captive populations of wildlife where full pedigrees are available and careful data collection and analysis is possible. In the absence of similar data for wild populations – as is the case here for

CWTD subpopulations in the Columbia River DPS – we must use these data across multiple species as a general guide for estimating the strength of inbreeding depression in our models. We have chosen to use an estimate of 3.0 lethal equivalents in our models, which is similar to that estimated for captive populations of mammals (Ralls et al. 1988) but likely represents a low estimate when compared against other estimates generated from surveys across an array of wildlife populations (O'Grady et al. 2006). It may be argued that these relatively small CWTD subpopulations have already experienced some level of inbreeding in the past, and undergone a process known as "purging" of at least a portion of the collective load of deleterious genes that cause inbreeding depression.

In addition to specifying the strength of inbreeding depression, we may utilize available genetic information on the subpopulations themselves to estimate the current extent of inbreeding. This improves the realism of our models over the default assumption that there is no inbreeding currently occurring in the subpopulations, i.e., all individuals in the starting populations are unrelated (clearly an unrealistic assumption). Recent population genetic analysis by T. Piaggio (unpublished data) suggests that the mean inbreeding coefficient among individuals occupying the most downstream subpopulations (JBH to Westport-Crims) is on the order of 0.10. We use this information to assign a mean inbreeding coefficient to all individuals inhabiting a given subpopulation. The inbreeding depression characterized by the number of lethal equivalents specified above will therefore be expressed immediately in the simulation.

Demographic Sensitivity Analysis

A sensitivity test was conducted in order to evaluate how uncertainty around a suite of model input parameters affects the population stochastic growth rate. A total of 100 iterations were run for each of 1000 randomly selected combinations of input parameters, with each parameter sampled from specified ranges. The selected parameters were evenly spaced across their respective ranges, with the sampling done according to a "Latin hypercube" scheme (Iman et al. 1981) so that the combinations of sampled rates were evenly distributed across the *n*-dimensional space represented by the input parameter set. This sampling method provides high levels of statistical power for determining the effect of each sampled parameter on the output metric of interest – in this case, stochastic population growth rate.

Table 3 presents the input parameters included in the sensitivity analysis and the ranges sampled for each parameter. The ranges are meant to roughly correspond to biologically plausible minima/maxima for each parameter, and to reflect our extent of comparative uncertainty in the true values of each. We set the initial population abundance to be 164 individuals as in the JBH subpopulation, but increased the ecological carrying capacity to 320 individuals to allow for a wider range of stochastic population growth values as conditions warranted.

Table 3. Parameter values included in the demographic sensitivity analysis.

	Input Parameter Value		
Model Input Parameter	**Base**	**Minimum**	**Maximum**
No. lethal equivalents	3.0	0.0	6.0
% females breeding*	75.0 / 95.0	67.5 / 85.5	82.5 / 100
No. fawns born[†]	(90; 10; 0) / (0; 93; 7)	(99; 1; 0) / (0; 100; 0)	(81; 19; 0) / (0; 83.7; 16.3)
Fawn survival (%)[††]	30.0 / 15.0	20.0 / 3.0	40.0 / 27.0
Adult female survival (%)	85.0	80.0	90.0
Severe flood frequency (%)	3.0	0.0	10.0

* Parameter values expressed as [Age-2 / Age-2+]

[†] Parameter values expressed as [% singles ; % twins ; % triplets] per [Age-2 / Age-2+] breeding female

[††] Parameter values expressed as [low density (N < 0.5K) / high density (N = K)]

Note that this form of sensitivity analysis is different from a more formalized analysis of sensitivity and elasticity (proportional sensitivity) that is associated with matrix-based approaches to simulations of wildlife population dynamics (e.g., Caswell 2000). Our goal here was to explore the impact of parametric uncertainty across a suite of model inputs that are on different numerical scales and have different degrees of uncertainty. These complexities hinder the proper application and interpretation of traditional elasticity analyses (Manlik et al. 2017) and prompt the adoption of a simplified approach to exploration of parameter uncertainty.

Simulating Impacts of Threats to CWTD Viability

As a result of the preceding discussion of subpopulation-specific threats (Figure 3), it was decided to construct a series of scenarios that explored the potential impacts of selected threatening processes on subpopulation viability. Specifically, threats impacting habitat availability (rising ground water, increased agricultural activity and urbanization, and expanding distribution of invasive species) were simulated by gradually decreasing the carrying capacity of each subpopulation over a period of 50 years. Unfortunately, we are unable to construct an accurate description of the mechanistic relationship between any one of these processes and its impact on CWTD habitat carrying capacity. Nevertheless, the PVA tool can be used to explore a plausible representative scenario where a specified proportion of deer habitat is gradually lost over time as a consequence of the combined action of multiple threatening processes. Those subpopulations composed primarily of public lands – JBH, Tennasillahe, Sauvie – Scappoose, and Morgan / Ridgefield / Shillapoo – had carrying capacity decreased by 0.75% per year in the first 50 years, while the remaining subpopulations composed of private lands had carrying capacity decreased by 1% over the same time period. This is simulated as a linear decline in carrying capacity over time relative to the initial value. Consequently, the carrying capacity at year 50 would decrease by 37.5% and 50% of their initial values in public and private lands, respectively. Beginning at year 51 of the simulation, the carrying capacity was assumed to remain constant. These rules were intended to represent targeted habitat management in those subpopulations where deer habitat may/would be managed more intensively. In reality, deer habitat may be lost relatively more slowly or more rapidly, but it is our hope that this scenario provides insight into the potential impact of some level of future habitat loss.

In a similar manner, we explored the potential impacts of an increase in the frequency of severe flooding events across the DPS. Recent climate change forecasts (Glick et al. 2007) suggest that sea levels may rise in the Pacific Northwest by as much as a foot by 2050. Since the DPS is alongside a tidally-influenced stretch of the Columbia River, this rise could increase the frequency of severe flooding events over the coming decades. To simulate this, we created additional scenarios where the annual probability of the flooding event increased linearly over 50 years from the baseline value of 3% to 10%. We assumed that the impact of the flooding event would remain constant over the course of the simulation. As with the habitat loss scenarios, there is considerably uncertainty around current and future flooding frequencies and impacts across the subpopulations making up the DPS. In light of this, we must consider these scenarios as exploratory and indicative of possible future impacts.

Simulations were run separately with the addition of either habitat loss or with increased flood frequency. A final set of simulations was run where both threats were added to the analysis.

<u>Metapopulation Management Scenarios</u>

A set of scenarios was constructed to investigate specific proposed alternatives for CWTD management along the lower Columbia River. These alternatives are discussed in detail below.

Translocation from Tennasillahe to Columbia Stock Ranch: A specific management option involves transfer of deer from Tennasillahe Island to Columbia Stock Ranch, near the northern portion of Deer Island. This option is simply intended to facilitate the establishment of a robust CWTD population in the Columbia Stock Ranch / Deer Island unit, without the need to rely on natural dispersal mechanics to augment the existing number of animals. For the purposes of this PVA-based evaluation, we assume that the translocation program has the following general characteristics:

- The translocations would take place in Years 1 and 2 of the simulation;
- A total of either 50 individuals (25 each year) or 80 individuals (40 each year) would be translocated;
- Each year's cohort of translocated individuals would be composed of approximately 70% does (annual cohort of 25 deer: 17 does, 5 bucks, and 3 fawns; annual cohort of 40 deer: 29 does, 14 bucks, 7 fawns);
- An average of approximately 10% additional annual mortality in each cohort that can be attributed directly to the translocation procedure.

Deer translocation from Tennasillahe in response to salmon restoration planning (Version 1): The US Fish and Wildlife Service is evaluating the feasibility of creating additional spawning habitat for Columbia River salmon (*Oncorhynchus* sp.) near Tennasillahe Island. This activity would involve creating multiple breaches of the dikes surrounding the island, thereby flooding most of the habitat available for white-tailed deer that would be on the island at the time. To mitigate the impact to the resident deer population, the bulk of the animals would be translocated to other local subpopulations. For the purposes of this PVA-based evaluation, we assume that the translocation program has the following general characteristics:

- 25 individuals would be translocated each year for seven years;
- Each year's cohort of translocated individuals would be composed of approximately 70% does (17 does, 5 bucks, and 3 fawns);
- An average of approximately 10% additional annual mortality in each cohort that can be attributed directly to the translocation procedure;
- Deer are moved in Years 1 and 2 to the Columbia Stock Ranch; to the Sauvie – Scappoose area in Years 4 and 5; and to the Westport – Crims area in Years 6-8. Note that no translocations occur in Year 3 in order to evaluate the success of the initial efforts targeting deer for the Stock Ranch.

These scenarios also feature simulated changes to local carrying capacities as a result of specific habitat management activities. Specifically:

- Columbia Stock Ranch / Deer Island carrying capacity increases from its initial value of 138 to 152 as a result of local improvements to habitat in CSR;
- Westport – Crims carrying capacity increases in Year 3 from its initial value of 250 to 325 as a result of local improvements in the Greenwood Marshlands area;
- Tennasillahe carrying capacity declines from its initial value of 200 to 20 in Year 9 after dikes are breached.

Finally, we assume that once the Tennasillahe dikes are breached in Year 9 of the simulation, dispersal into Tennasillahe from both the JBH and the Puget subpopulations drops to 0 as animals recognize little to no available habitat on the now largely flooded island. In a similar context, we assume that dispersal probabilities of the remaining deer off of Tennasillahe and on to JBH in Year 9 increase from a mean annual rate of 5% to 15% and on to Puget Island from 2.5% to 7.5% in that same year. This mechanic is meant to simulate desire on the part of the remaining individuals to leave the presumably deteriorated remnant habitat after the dikes are breached.

This translocation scenario is run under the four general environmental alternatives used in the models already described (baseline/no change, increased flooding risk, habitat loss, and combined flood risk and habitat loss). Moreover, we tested this translocation scenario across each of the three population growth alternatives described previously. Therefore, our analysis features a total of twelve scenarios evaluating the impact of CWTD translocation in the presence of salmon restoration management on Tennasillahe Island.

Deer translocation from Tennasillahe in response to salmon restoration planning (Version 2): A second set of scenarios was developed for this salmon habitat management option, differing only in the set of subpopulations targeted for receiving deer moved off of Tennasillahe prior to breaching the dikes on the island. Specifically, this scenario explores the potential benefit of using about 2000 acres of mostly county-owned land near the East Fork of the Lewis River, just to the east of the Morgan / Ridgefield / Shillapoo complex in the southeastern portion of the current CWTD distribution. Based on the same type of ecological calculations discussed above, this new habitat area is assumed to have a CWTD carrying capacity of 400 individuals. Additionally, the area has some small degree of demographic connectivity to the Morgan / Ridgefield / Shillapoo subpopulation, with a reciprocal annual rate of dispersal set at 0.5%. Deer do not currently inhabit this area, so the initial population size is set in all appropriate scenarios to zero. For the purposes of this PVA-based evaluation, we assume that the translocation program has the following general characteristics:

- 25 individuals would be translocated each year for seven years;
- Each year's cohort of translocated individuals would be composed of approximately 70% does (17 does, 5 bucks, and 3 fawns);
- An average of approximately 10% additional annual mortality in each cohort that can be attributed directly to the translocation procedure;
- Deer are moved in Years 1 and 2 to the Columbia Stock Ranch, northern Deer Island; to the Westport – Crims area in Years 4-6; and to the East Fork Lewis River area in Years 7 and 8. Note that, as before, no translocations occur in Year 3 in order to evaluate the success of the initial efforts targeting deer for the Stock Ranch.

All other metapopulation characteristics of this set of scenarios are identical to those described above in Version 1 of the proposed translocation program.

Targeted habitat management in Group B subpopulations: The Group B subpopulations (Willow Grove – Fisher / Hump, Lord / Walker / Dibblee, and Wasser – Winter / Kalama) could potentially serve a vital role in maintaining functional connectivity dynamics across the existing CWTD metapopulation, being a bridge of sorts that link the larger habitat areas both upstream and downstream. Therefore, a set of scenarios was constructed that assessed the impact of targeted habitat improvements in these three subpopulations.

All habitat management scenarios featured a mean expected annual subpopulation growth rate of 0.02. Carrying capacity (*K*) in each Group B subpopulation was increased by 25%, 50%, or 75% of the baseline value set for all previous simulations. The specified increase in *K* was assumed to be linear over the first five years of the simulation, and as a constant proportion of the initial value for each subpopulation (Table 4). For example, the "*K* +50%" scenario for the Lord / Walker / Dibblee scenario features a linear increase in carrying capacity from 81 to 121 over simulation years 1 to 5, in annual increments of 8 individuals.

Table 4. Carrying capacity (*K*) values used for the Group B subpopulation habitat management scenarios described in the text.

	Management Scenario			
Subpopulation	Baseline *K*	*K* +25%	*K* +50%	*K* +75%
Willow Grove – Fisher / Hump	61	76	91	106
Lord / Walker / Dibblee	81	101	121	141
Wasser – Winter / Kalama	52	67	77	92

General Model Characteristics

All scenarios projected subpopulation dynamics over a period of 100 years, with each scenario repeated 1,000 times in order to assess the impact of stochastic variation in demographic and genetic processes as described in the previous sections. Despite projecting population dynamics over this longer time period, we can explore subpopulation characteristics at shorter time intervals to inform management over more tractable time scales. The PVA was conducted using *Vortex* version 10.3.5 (16 October 2018).

Results of Simulation Modeling

Confirmation of Selected Model Performance Elements

Before discussing the detailed results of specific scenarios, it is instructive to briefly review the broad demographic performance of simulated Columbian white-tailed deer populations in a representative scenario. In particular, it is important to confirm the reproductive performance of the simulated populations, as this is the aspect of the taxon's life history that is evaluated each year through detailed field surveys. A summary of the relevant demographic model output is presented below for a typical simulated CWTD population.

- Mean fawn:doe ratio: 0.40 – 0.45. This is calculated in our model after both reproduction and mortality events have taken place as

[# fawns] / [(# yearling females) + (# adult females)].

This is roughly equivalent to the protocol that is used in the field to estimate this parameter, where fawns are typically born in June and field surveys are conducted during the following November – December. In developing these calculations, we assume that the large majority of fawn mortality takes place in the first six months after the fawns are born. Data provided by the US Fish and Wildlife Service for upstream subpopulations (JBH to Lord / Walker / Dibblee) since 2004 give mean fawn:doe ratios of 0.30 – 0.45.

- Mean buck:doe ratio: 0.35 – 0.37. This parameter is calculated similarly to the buck:doe ratio, where both yearlings and adults of both sexes are included in the calculation procedure. Again, recent field data from downstream subpopulations indicate typical buck:doe ratios in the range of 0.30 – 0.40, as has been reported for CWTD in the past (Gavin et al. 1984) and for other white-tailed deer populations.

Based on this information, we believe our prospective models can be viewed as internally consistent and generating population dynamics that agree with baseline expectations of Columbian white-tailed deer demographic characteristics.

Demographic Sensitivity Analysis

Among the model input parameters chosen for this analysis, and over the ranges of parameter values chosen for testing as a reflection of our relative uncertainty in these values, survival of both fawns and adult females dominates variance in stochastic growth (Table 5). The strength of inbreeding depression, measured by the number of lethal equivalents present among individuals in the subpopulation, and the frequency of severe flooding events explain a relatively modest amount of the total variance in population growth. Measures of fawn production (% females breeding and total fawns born) explained relatively little of the overall variance in population growth rate.

Table 5. Results from demographic sensitivity analysis. r_s (Min) and r_s (Max), stochastic population growth rates for the minimum and maximum values of the uncertain model input parameters listed in Table 3. Variance in population growth expressed as a percentage of the total variance accounted for by all parameters through multivariate regression.

Model Input Parameter	r_s (Min)	r_s (Max)	% Variance Explained†
No. lethal equivalents	0.0105	-0.0198	7.35
% Females breeding	-0.0142	0.0036	2.68
No. fawns born	-0.0051	0.0037	0.86
Fawn survival (%)	-0.0631	0.0319	54.71
Adult female survival (%)	-0.0409	0.0201	26.79
Severe flood frequency (%)	0.0060	-0.0245	5.05

† %Variance explained by regression error: 2.58

These results are intended to reflect a combination of the influence of a given demographic parameter on population growth, and our level of uncertainty in specifying the value of that parameter. As such, this is not a formal sensitivity (elasticity) analysis that provides insight into the proportional contribution made by each parameter to the stochastic population growth rate. An elasticity analysis of this type was performed with the baseline parameters listed in Table 3, using the matrix-based demographic analysis software package *RAMAS Metapop* (Akçakaya and Root 2007). The analysis (not reported here in detail for simplicity), focusing only on survival and fecundity parameters as dictated by a typical age-structured matrix approach to population analysis, demonstrated adult female survival to have the highest elasticity of all demographic rates tested. This is expected for a typical ungulate species (e.g., Gaillard et al. 2000) and has recently been reported for a population of white-tailed deer in the southeastern United States (Chitwood et al. 2015). However, we are likely to have relatively more confidence in our estimates of adult female survival compared to fawn survival, which is reflected in the structure of our uncertainty analysis (Table 3) and the corresponding results (Table 5). Additionally, it is likely that fawn survival rates are more highly variable across years, and are subject to greater manipulation through management of threats such as coyote predation. This may have implications for future demographic data collection strategies and population management decisions across the DPS.

Risk Analysis: Quasi-extinction Threshold Plots in Assessment of PVA Model Runs

Before presenting the results of our risk analysis, it may be instructive to explain the output metric used in the figures in this section: the probability of quasi-extinction. For our purposes, quasi-extinction risk is defined as the probability that the mean subpopulation abundance will be below any given threshold value at some defined point in the future (Ginzburg et al. 1982). An example of a quasi-extinction threshold plot is given in Figure 5.

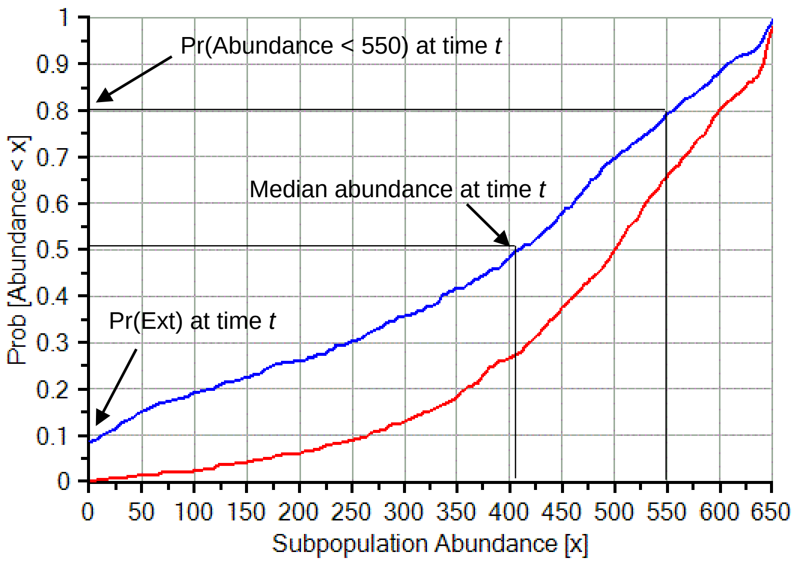


Figure 5. Representative quasi-extinction threshold plot for two generic alternative PVA scenarios, with salient features labeled.

As demonstrated in this figure, a quasi-extinction threshold plot conveys a significant amount of information, including:

- Estimated risk of total extinction for the population at the specified point in time, indicated by the intersection of the curve with the *y*-axis. In the figure above, the scenario corresponding to the blue line shows an extinction risk of approximately 0.09. This may be a slight underestimate of the true probability of extinction, as *Vortex* includes the presence of only one sex in its definition of extinction.
- Estimated median population abundance at the specified point in time, which is roughly equivalent to a 50% probability that the final abundance is below the threshold. In the figure above, the scenario corresponding to the blue line shows a mean population abundance at time *t* of just over 400 individuals. With a knowledge of the initial population abundance, it is evident if the population has grown or declined in abundance over the course of the simulation.
- Estimated probability of the population abundance at time *t* being less than a given threshold value. In the figure above, the scenario corresponding to the blue line shows that the probability of the population abundance being less than 550 individuals at time *t* to be just under 0.8.
- Comparative performance of alternative scenarios. In the figure above, we can conclude that the scenario represented by the blue line is performing more poorly than its counterpart shown by the red line: extinction risk is greater (0.09 vs. 0.0), and the mean population abundance at time *t* is lower (about 400 vs. 500).

Based on the above observations, quasi-extinction threshold calculations are regarded as providing valuable insights into population dynamics and viability in PVAs (Morris and Doak 2002).

Risk Analysis I: Impact of Demographic Connectivity among Subpopulations

Given the uncertainty in the extent of demographic connectivity as a feature of CWTD metapopulation dynamics in the Columbia River DPS, it is helpful to evaluate the impact of alternative dispersal scenarios among representative subpopulations in our PVA model. Therefore, we constructed three sets of scenarios for each of the three growth rate assumptions (see section on model input) featured in our analysis: (*i*) no dispersal, with subpopulations therefore demographically isolated from one another; (*ii*) baseline dispersal, with rates defined by the dispersal matrix (Figure 2), and (*iii*) restricted dispersal, with dispersal rates estimated to be reduced by 50% relative to the baseline dispersal matrix values. We focus our attention in this analysis on two different types of subpopulations within the DPS: a relatively larger subpopulation that is currently very near its ecological carrying capacity, such as JBH; and a smaller subpopulation that is far below its carrying capacity, such as Columbia Stock Ranch / Deer Island.

The larger JBH subpopulation is influenced relatively little by the extent of demographic connectivity with its nearest neighbors (Tennasillahe and Puget Island), with the largest comparative effect present under conditions of low expected population growth (Figure 6). The results of our analysis are markedly different for the smaller Columbia Stock Ranch / Deer Island sub population, where connectivity to both upstream and downstream subpopulations greatly influence its long-term viability. The probability of Columbia Stock Ranch / Deer Island subpopulation extinction is at least 0.6 after 50 years, under conditions of relatively high mean annual growth, and increases to more than 0.9 if growth is restricted due to higher fawn mortality. The presence of at least some connectivity with its nearest neighbors greatly decreases extinction risk, and significantly increases the opportunity for subpopulation expansion under conditions of positive long-term population growth.

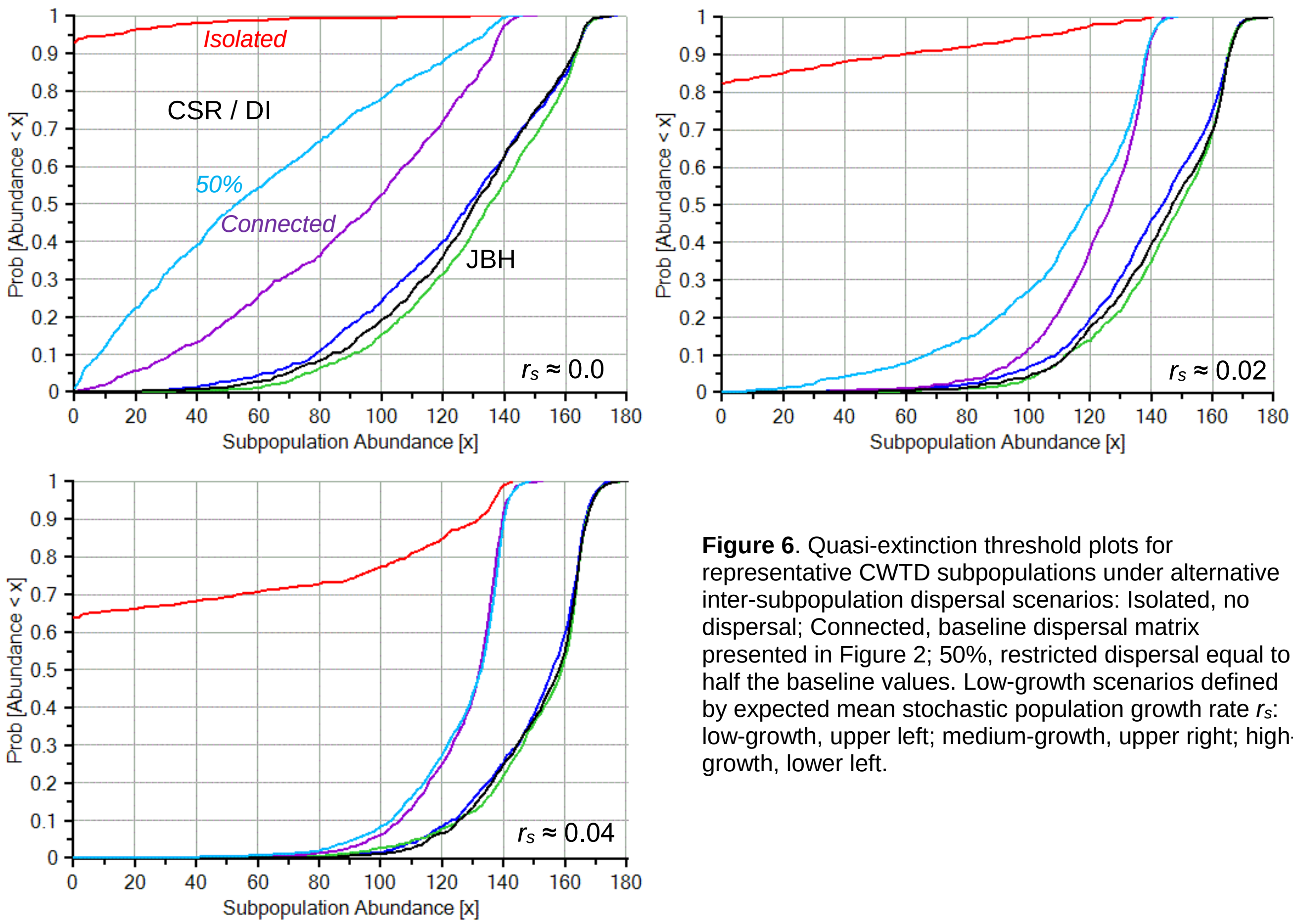


Figure 6. Quasi-extinction threshold plots for representative CWTD subpopulations under alternative inter-subpopulation dispersal scenarios: Isolated, no dispersal; Connected, baseline dispersal matrix presented in Figure 2; 50%, restricted dispersal equal to half the baseline values. Low-growth scenarios defined by expected mean stochastic population growth rate r_s: low-growth, upper left; medium-growth, upper right; high-growth, lower left.

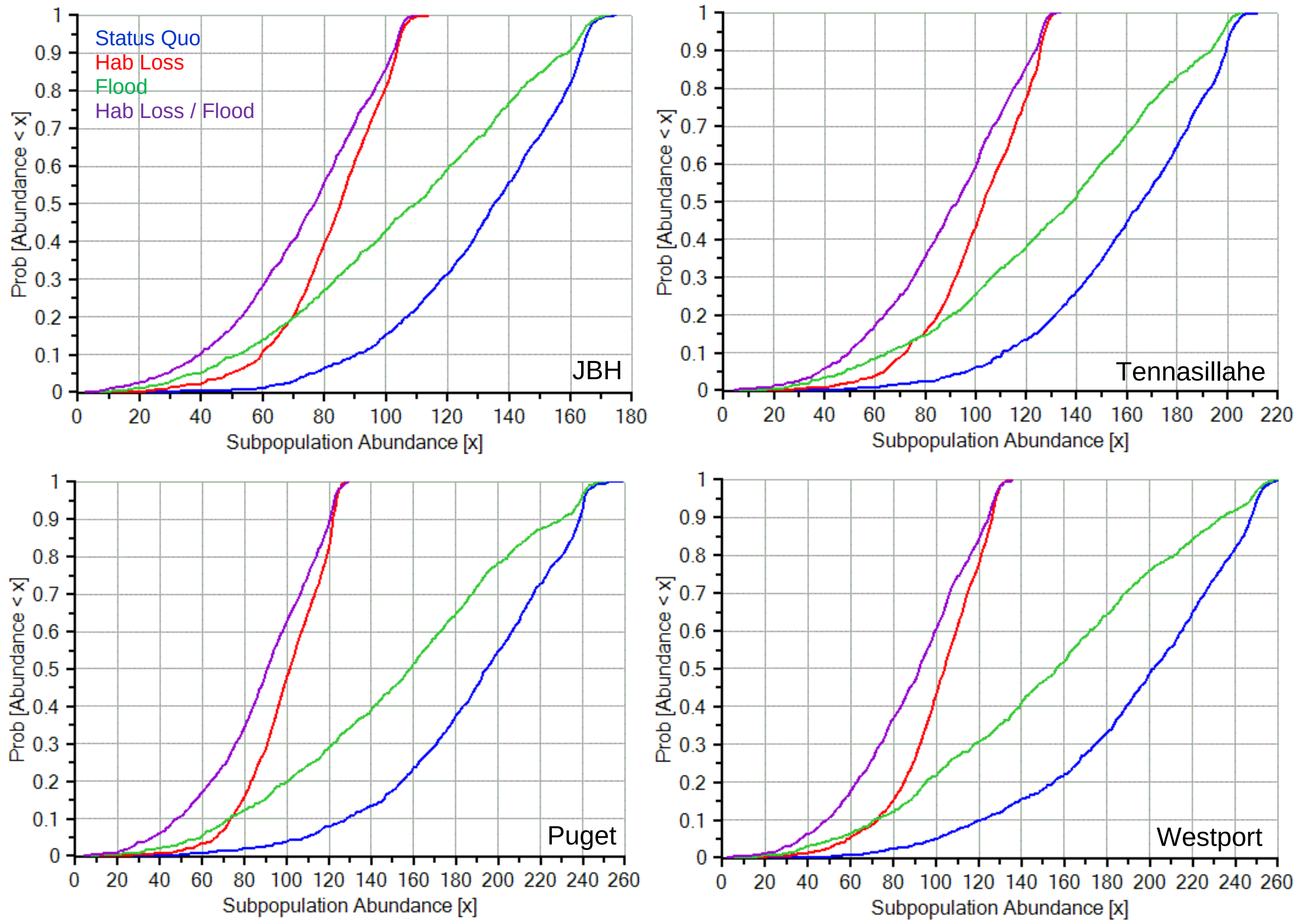
These results suggest that the viability of smaller subpopulations across the DPS is improved by the presence of demographic connectivity with their neighbors. Additionally, the opportunities for expansion of the smaller subpopulations at the upstream end of the DPS are significantly enhanced, particularly if survival rates are managed such that intrinsic growth in subpopulation abundance is possible.

Risk Analysis II: Threat Analysis under Low-Growth Conditions

Group A subpopulations, low growth

If proposed threats from habitat loss and increased flooding events are absent from the model, we are assuming a "status quo" situation were current conditions are expected to persist into the future. Under this assumption, Group A subpopulations persist into the future and establish a long-term equilibrium abundance that is somewhat lower than their original abundance values (Figure 7). This is due to the stated carrying capacity being a reflecting ceiling boundary, preventing the simulated subpopulation from growing beyond the stated maximum abundance.

Figure 7. Quasi-extinction threshold plots at simulation year 50 for Group A subpopulations under the range of threat scenarios, assuming low population growth (r_S = 0.00) and baseline dispersal rates.



Increasing the frequency of severe flooding events further reduces population abundance at year 50 by an additional 20-25%, with the habitat loss scenarios resulting in even greater reductions in abundance. If both threatening events are included, subpopulation growth rates are further depressed and mean abundances are reduced to approximately 50% of the status quo value. Furthermore, the risk of these subpopulations declining to less than 50 individuals – currently identified as a condition for subpopulation viability in the existing Recovery Plan – increases to approximately 0.1 to 0.2 in the next 50 years.

Group B subpopulations, low growth

The smaller Group B subpopulations display very similar qualitative dynamics to their Group A counterparts in these low-growth scenarios (Figure 8). However, the restricted growth opportunities examined here mean that the risk of these subpopulations dropping below the threshold abundance of 50 individuals is quite high, even for the relatively benign status quo scenarios. This is also influenced by the fact that these subpopulations have carrying capacities of between 52 and 81. With lower growth rates, the subpopulations are more likely to decline in size in any given year as demographic stochasticity and inbreeding depression suppress survival and reproduction. There is even a slight risk of outright extinction at 50 years for the Lord / Walker / Dibblee and Wasser – Winter / Kalama subpopulations.

As habitat loss and flooding event threats are added to the models, growth rates are further reduced and the final mean abundances drop to as low as 10 (Wasser – Winter / Kalama) to 23 (Lord / Walker / Dibblee) individuals. Extinction risks over the 50-year simulation duration increase to approximately 0.05 – 0.15, with the Wasser – Winter / Kalama subpopulation at greatest risk.

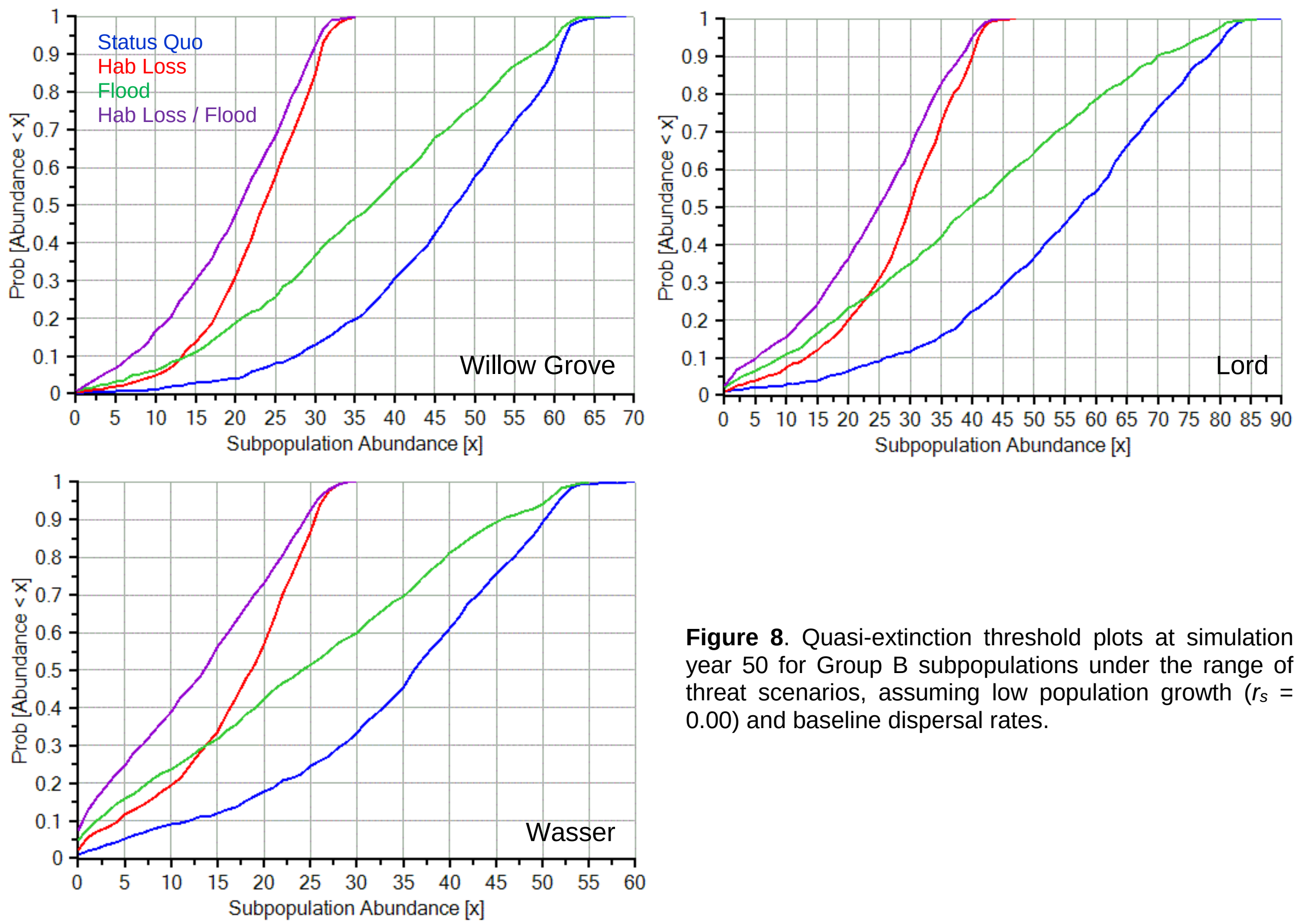


Figure 8. Quasi-extinction threshold plots at simulation year 50 for Group B subpopulations under the range of threat scenarios, assuming low population growth (r_s = 0.00) and baseline dispersal rates.

Group C subpopulations, low growth

In the absence of the proposed threats, the Columbia Stock Ranch / Deer Island subpopulation shows a tendency to increase in abundance even under the low-growth scenario (Figure 9). Note that the observed growth rate for this population (r_s = 0.037) is considerably higher than the expected mean rate of r_s = 0.0, due to the initial population size being far below the proposed carrying capacity and therefore triggering higher fawn survival rates at low population density. Despite this opportunity for growth, this subpopulation has a reasonable chance (approximately 0.17) of failing to increase in abundance beyond the N = 50 viability target. The other subpopulations show much greater demographic stability and are able to grow to more than 300 individuals if the proposed threats are absent from the simulations.

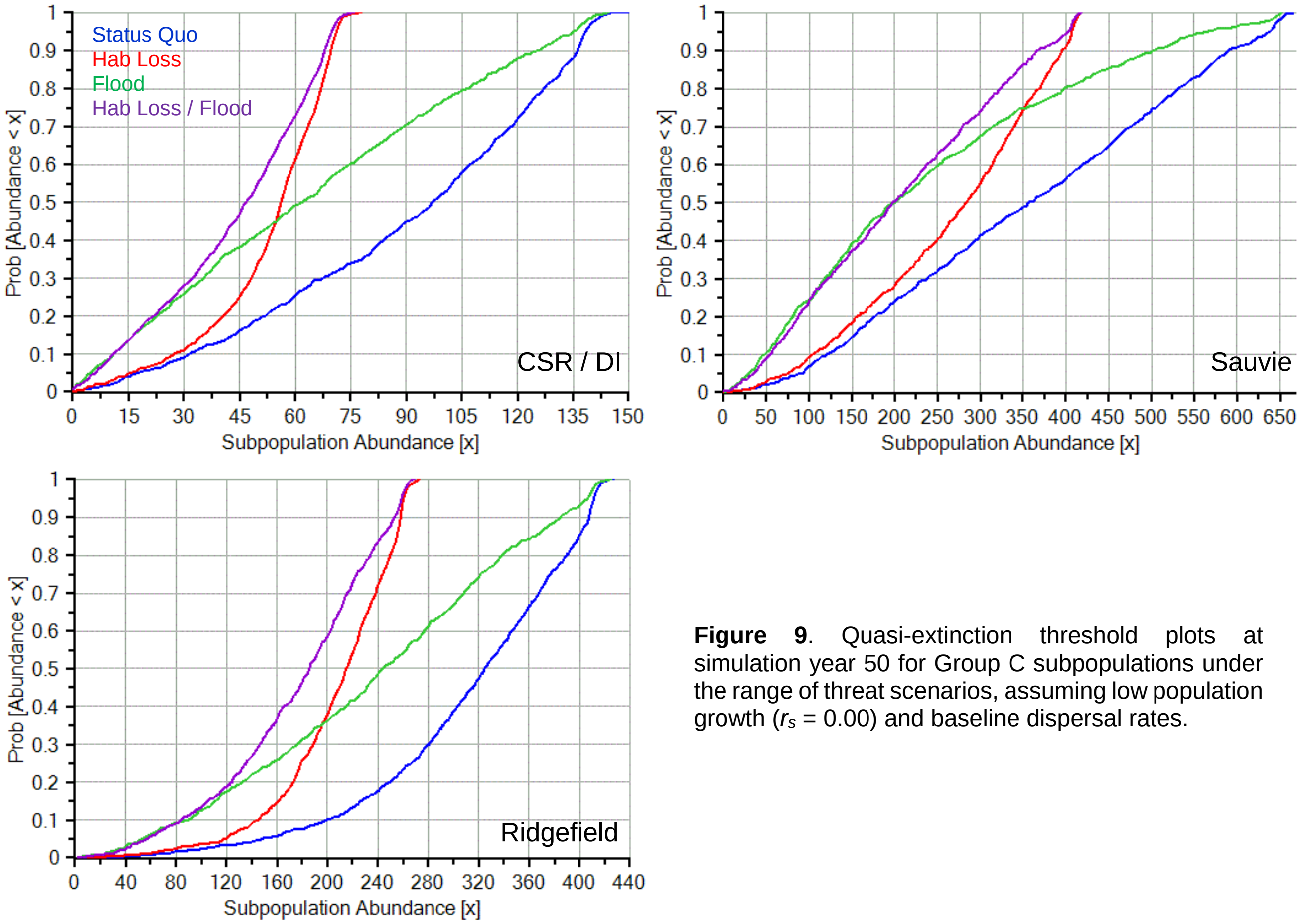
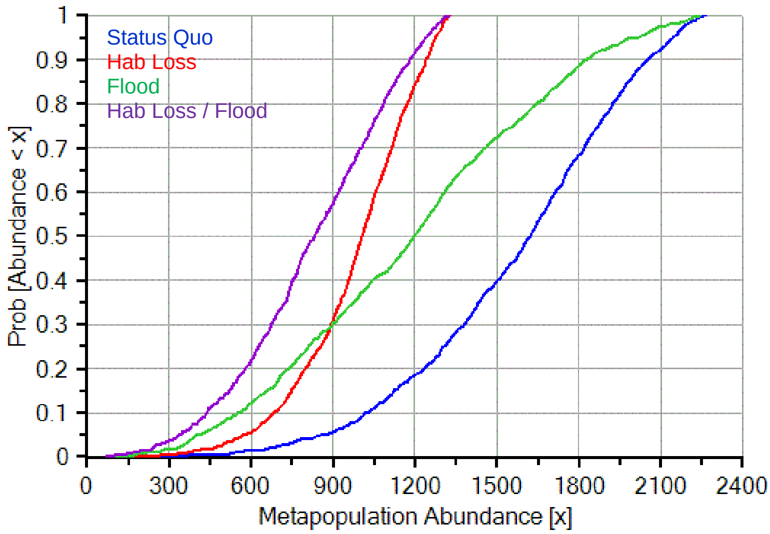


Figure 9. Quasi-extinction threshold plots at simulation year 50 for Group C subpopulations under the range of threat scenarios, assuming low population growth (r_s = 0.00) and baseline dispersal rates.

If threats are introduced, overall population viability is compromised. Introducing increased habitat loss and flood risk is particularly severe for the Columbia Stock Ranch / Deer Island population, where the subpopulation does not grow beyond about 75 individuals over the course of the simulation. Extinction risks, however, remain small because of the population's connectivity to the upstream Ridgefield and Sauvie – Scappoose subpopulations. Because of its larger initial abundance, and because of the relatively slower rate of habitat loss assumed to occur among the public lands that make up part of the subpopulation habitat, the Morgan / Ridgefield / Shillapoo subpopulation displays the greatest level of overall stability, with large mean subpopulation abundances at 50 years and a low risk of the abundance declining below 50 individuals.

Overall metapopulation, low growth
The total mean abundance of the combined subpopulations, in the absence of the proposed threats assessed in this analysis, increases from its initial value of 1224 individuals to a final value at simulation year 50 of approximately 1700 individuals, with a 50% probability of ending up below 1650 deer (Figure 10). Adding habitat loss and flooding threats to the models reduces this mean abundance to a minimum value of approximately 800 individuals, indicating a gradual decline in metapopulation abundance as demographic rates suffer from the threat impacts themselves and as inbreeding depression further reduces the viability of the smallest subpopulations. When both threats are included in the models, and as a function of the manner in which the demographic impacts of these threats were simulated in our PVA, there is a 7.5% risk that the overall metapopulation would decline below the *N* = 400 threshold currently identified in the Recovery Plan as diagnostic of a recovered DPS.

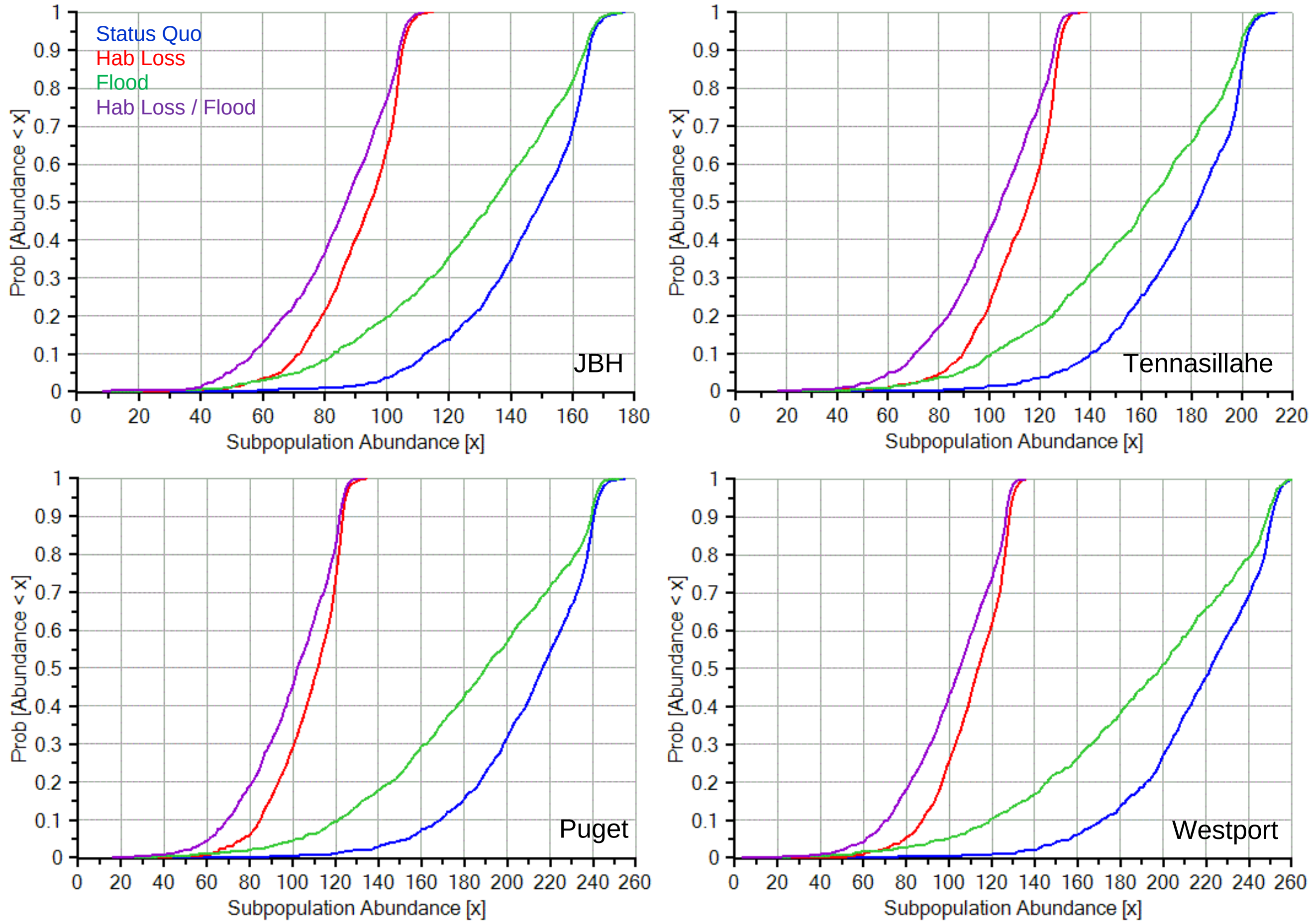
Figure 10. Quasi-extinction threshold plots at simulation year 50 for the metapopulation under the range of threat scenarios, assuming low population growth (r_s = 0.00) and baseline dispersal rates.



Risk Analysis III: Threat Analysis Under Medium-Growth Conditions

Group A subpopulations, medium growth
When a higher rate of intrinsic population growth is possible, owing to higher fawn survival defining our medium-growth scenarios (see page 9 for more information), subpopulation stability is increased. This is reflected in the quasi-extinction threshold curves for these subpopulations (Figure 11) shifting to the right as mean abundances at year 50 increases and with the likelihood of any one subpopulation falling below *N* = 50 decreasing. This can be seen directly by comparing curves in Figure 11 with the low-growth scenario curves for Group A subpopulations in Figure 7. Furthermore, it is evident that the impacts of the severe flooding event are lessened slightly as the increased growth potential in these scenarios allows the subpopulations to rebound more effectively following the flooding event. Finally, the risk of any Group A subpopulation falling below the stated viability threshold of *N* = 50 after 50 years does not exceed approximately 0.05. This represents a reduction in the risk of dropping below this threshold of up to 75% relative to the risk observed in the low-growth scenarios discussed earlier.

Figure 11. Quasi-extinction threshold plots at simulation year 50 for Group A subpopulations under the range of threat scenarios, assuming medium population growth (r_s = 0.02) and baseline dispersal rates.



Group B subpopulations, medium growth

An improved opportunity for subpopulation growth afforded in these medium-growth scenarios results in higher levels of relatively subpopulation stability and lower extinction risks (Figure 12). The relative impacts of the severe flooding event are attenuated in a manner similar to that for the Group A subpopulations, and the subpopulation extinction risks are smaller than the corresponding low-growth scenarios presented in Figure 8. However, the comparatively smaller habitat areas making up this subpopulation group means that subpopulation abundances remain small, and the potential for inbreeding depression reducing population growth remains significant. Under the habitat loss scenarios tested here, subpopulation abundances at year 50 do not exceed 45 individuals and may be as low as approximately 30 deer for Wasser – Winter / Kalama.

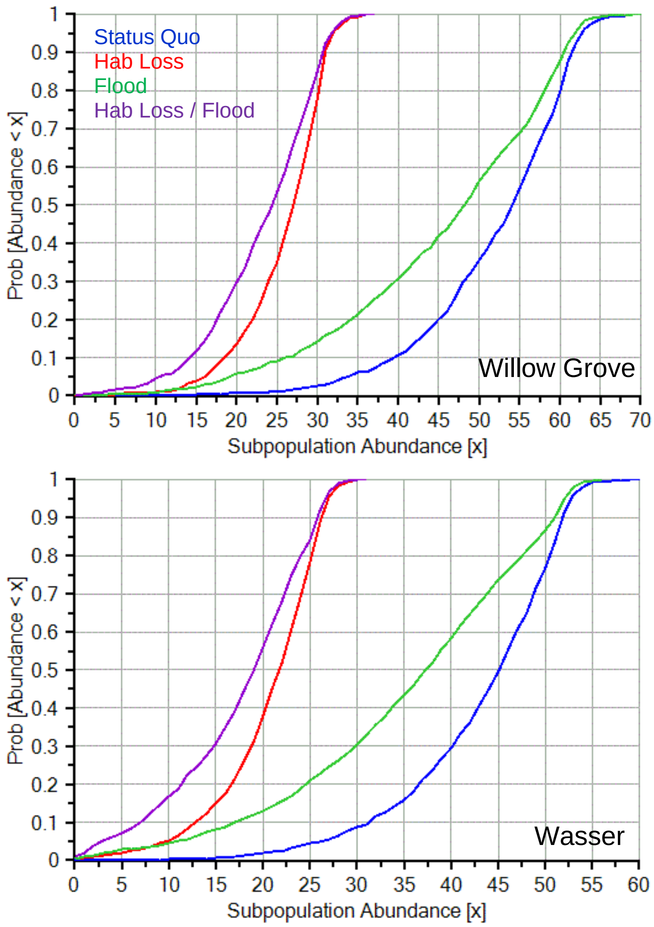


Figure 12. Quasi-extinction threshold plots at simulation year 50 for Group B subpopulations under the range of threat scenarios, assuming medium population growth (r_s = 0.02) and baseline dispersal rates.

Group C subpopulations, medium growth

The added benefit of higher rates of intrinsic population growth is most evident in the Columbia Stock Ranch / Deer Island subpopulation. Under the medium-growth scenarios tested here, the relative stability of this subpopulation is dramatically increased (Figure 13), although the risk of the subpopulation abundance at year 50 being below 50 individuals remains relatively for the combined threat scenario (probability of falling below 50 individuals ≈ 0.27).

The larger Sauvie – Scappoose and Morgan / Ridgefield / Shillapoo subpopulations demonstrate strong growth responses in the status quo and severe flood scenarios, with mean abundances at 50 years of approximately 475 – 575 (Sauvie) and 330 – 370 (Ridgefield). Note that with an estimated habitat carrying capacity of more than 600, the Sauvie – Scappoose subpopulation could potentially make considerable contributions to the overall subpopulation abundance if growth conditions are favorable.

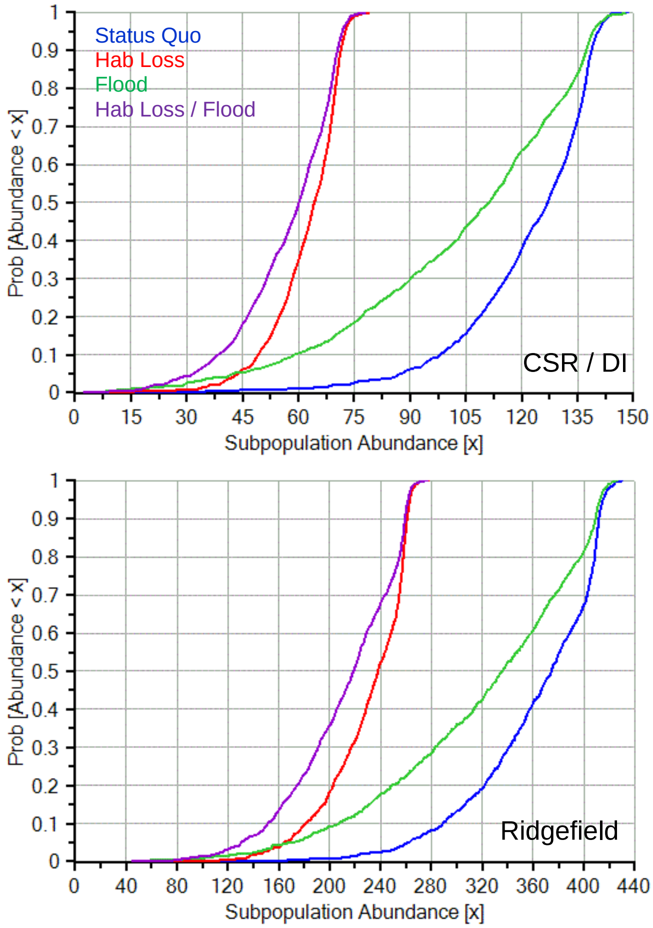
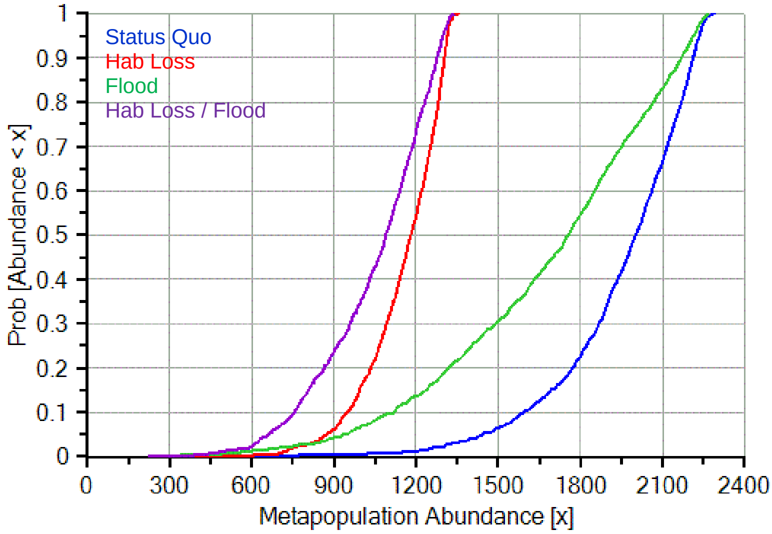


Figure 13. Quasi-extinction threshold plots at simulation year 50 for Group C subpopulations under the range of threat scenarios, assuming medium population growth (r_s = 0.02) and baseline dispersal rates.

Overall metapopulation, medium growth

As with each of the subpopulations, the overall metapopulation stability increases markedly in the medium-growth scenario as evidenced by a significant shift to the right of each curve in the quasi-extinction threshold plot seen in Figure 14. The risk of the metapopulation abundance dropping below the viability threshold of 400 individuals drops to negligible levels under the combined threat model, and the mean abundance under this scenario increases from 800 under the low-growth assumption to approximately 1100. The mean abundance increase slightly to just under 1200 individuals under a habitat-loss scenario, to approximately 1750 individuals under the increasing flood model, and to almost 2000 individuals if we assume that current conditions persist into the future (status quo).

Figure 14. Quasi-extinction threshold plots at simulation year 50 for the metapopulation under the range of threat scenarios, assuming medium population growth (r_s = 0.02) and baseline dispersal rates.

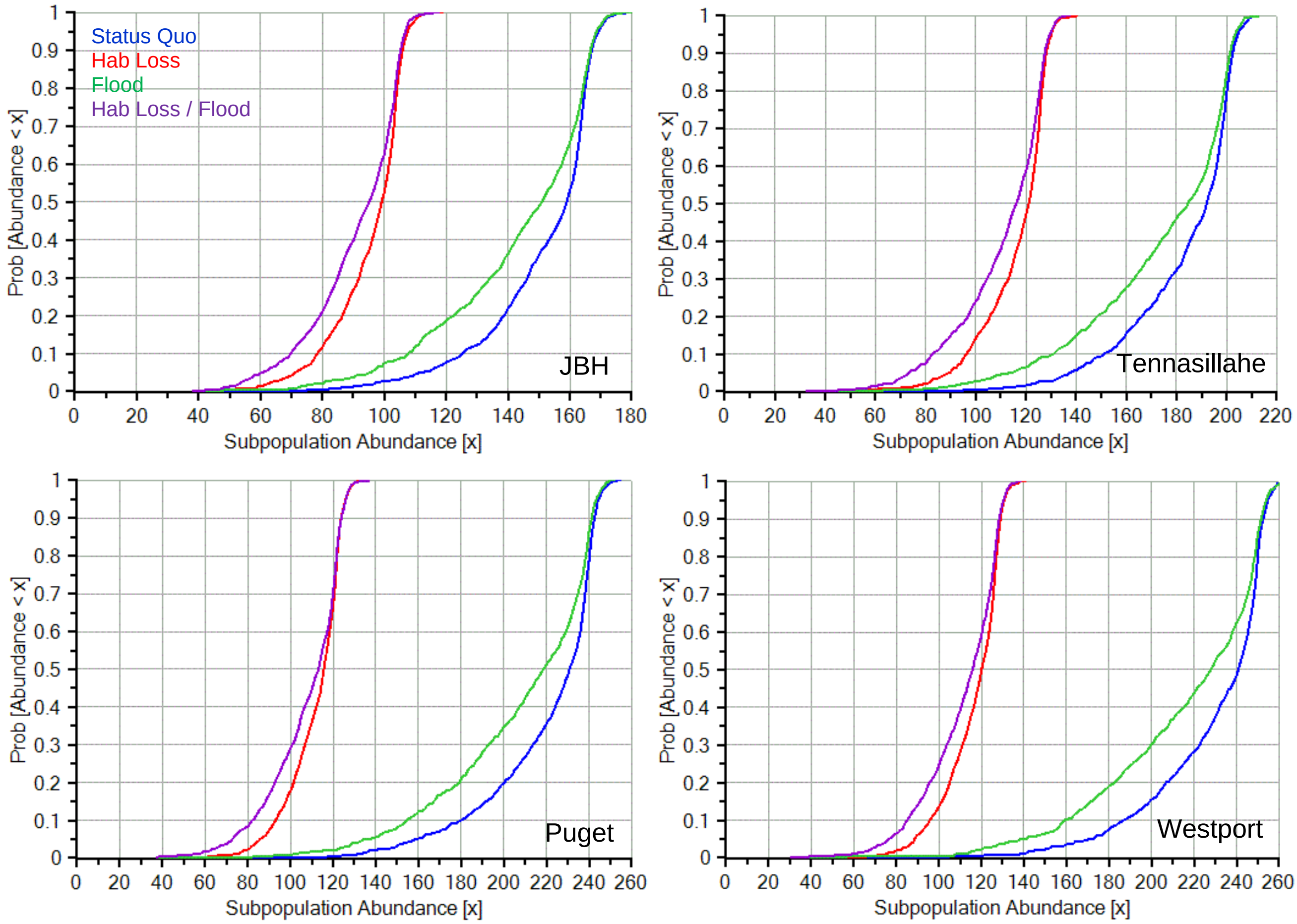


<u>Risk Analysis IV: Threat Analysis Under High-Growth Conditions</u>

Group A subpopulations, high growth

Higher growth rates resulting from additional increases in fawn and adult female survival in this set of scenarios yields further improvements to subpopulation stability. Mean abundances at simulation year 50 for this set of subpopulations equilibrate at a level that is just below initial abundances, with continued improvements in the ability to rebound from severe flooding events (Figure 15). Of course, this enhanced growth dynamic does not offset a loss of habitat, which results in a 40% to 50% reduction in abundance at simulation year 50 for the subpopulations comprising this group.

Figure 15. Quasi-extinction threshold plots at simulation year 50 for Group A subpopulations under the range of threat scenarios, assuming high population growth (r_s = 0.04) and baseline dispersal rates.



Group B subpopulations, high growth

Demographic improvement under expectations of more vigorous population growth is also evident in the smaller subpopulations making up Group B (Figure 16). The Lord / Walker / Dibblee subpopulation is likely to remain very close to the stated ecological carrying capacity, with only a small chance of falling below 50 individuals at simulation year 50 even with an increased frequency of flooding events. The other two subpopulations in this group also rapidly reach a stable equilibrium abundance just below their initial abundance when habitat loss is absent from the model; however, it is unlikely once again for these subpopulations to achieve the N = 50 viability target even under this most favorable growth scenario because of the lower carrying capacity values. Models including the habitat loss scenario result in the same kinds of significant declines in long-term subpopulation abundance, despite the high growth potential leading to negligible extinction rates.

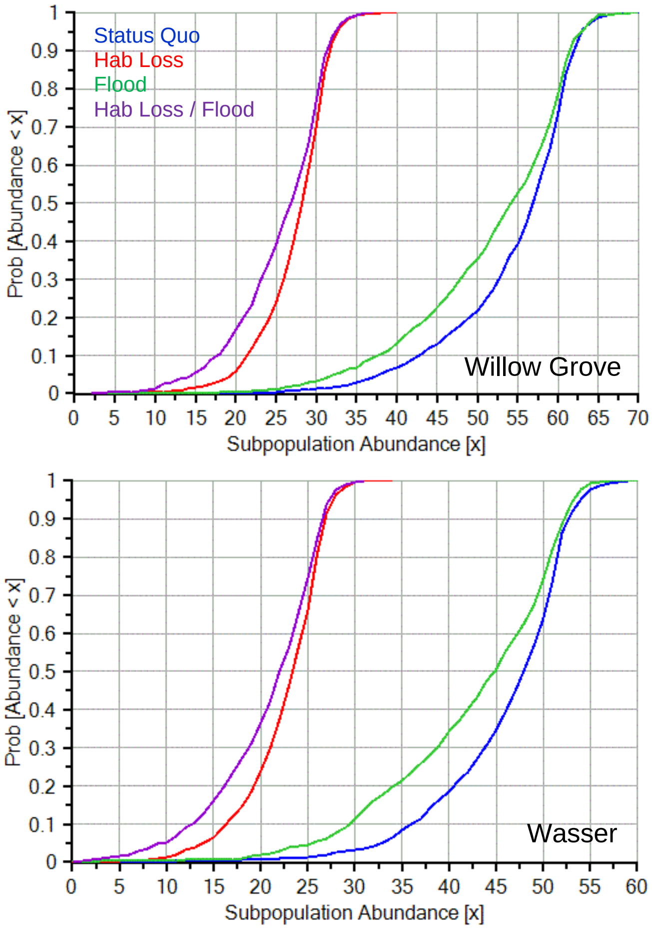


Figure 16. Quasi-extinction threshold plots at simulation year 50 for Group B subpopulations under the range of threat scenarios, assuming high population growth (r_s = 0.04) and baseline dispersal rates.

Group C subpopulations, high growth
As with the medium-growth scenarios, the Columbia Stock Ranch / Deer Island subpopulation has a very high probability of becoming established and growing to 140 – 150 individuals in the absence of increased habitat loss (Figure 17). Moreover, the risk of this subpopulation dropping below the current viability target (N = 50) is negligible if habitat loss is not part of the simulation. Even when habitat loss is included, mean Columbia Stock Ranch / Deer Island abundances at simulation year 50 exceed 60 individuals with only a 10% risk of dropping to less than the viability target.

The Sauvie – Scappoose and Morgan / Ridgefield / Shillapoo subpopulations show high levels of viability under these favorable growth conditions, growing to 580 – 620 and 380 – 400, respectively, at simulation year 50 in the absence of simulated habitat loss. Inclusion of this threat reduces these abundances to 370 – 390 and 240 – 250, respectively. Risks of either subpopulation dropping below the viability abundance target of N = 50 are negligible.

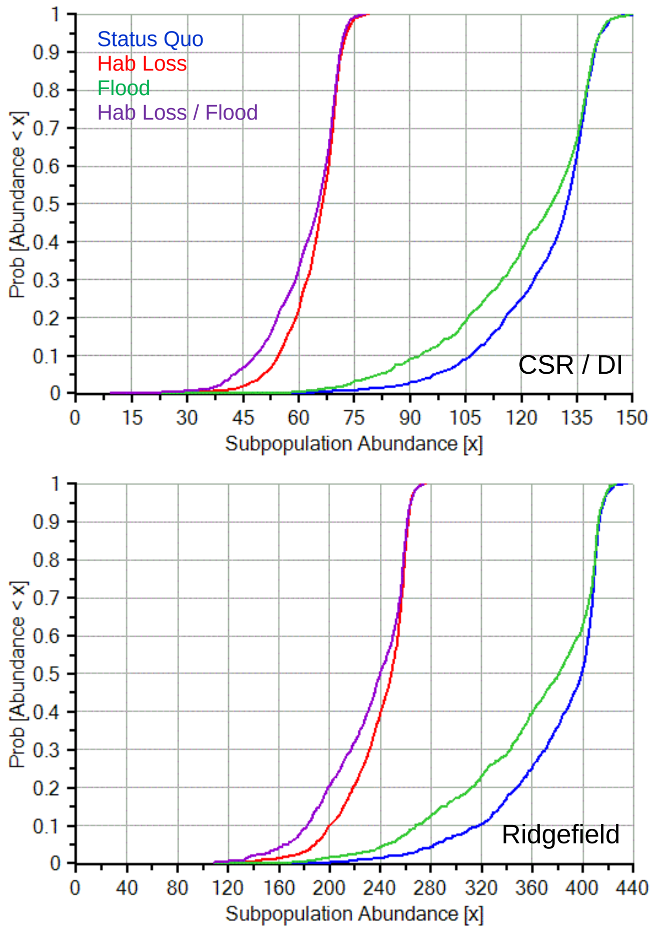
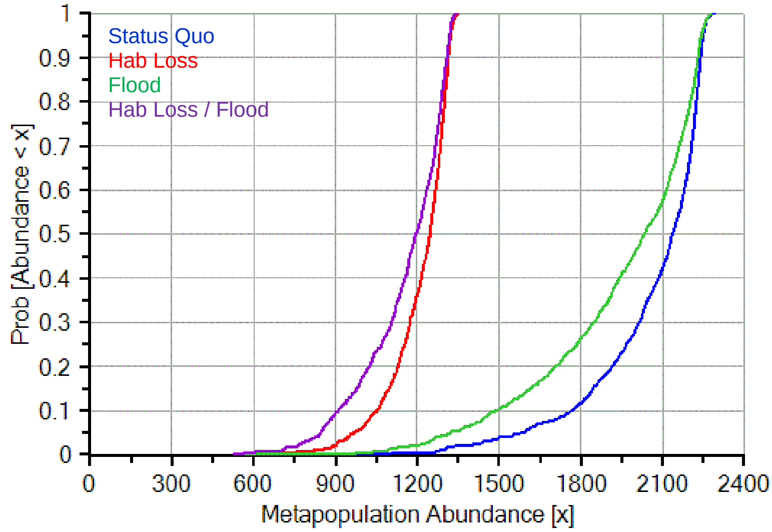


Figure 17. Quasi-extinction threshold plots at simulation year 50 for Group C subpopulations under the range of threat scenarios, assuming high population growth (r_s = 0.04) and baseline dispersal rates.

Overall metapopulation, high growth

Metapopulation stability continues to increase in the high-growth scenario (Figure 18). The risk of the metapopulation abundance dropping below the viability threshold of 400 individuals remains negligible under the combined threat model, and the mean abundance under this scenario increases from 800 under the low-growth assumption to approximately 1200. The mean abundance increases slightly to just over 1250 individuals under a habitat-loss scenario, to approximately 2000 individuals under the increasing flood model, and to over 2100 individuals if we assume that current conditions persist into the future (status quo).

Figure 18. Quasi-extinction threshold plots at simulation year 50 for the metapopulation under the range of threat scenarios, assuming high population growth (r_s = 0.04) and baseline dispersal rates.



Risk Analysis V: Translocation from Tennasillahe to Columbia Stock Ranch

A basic translocation of deer from the source population on Tennasillahe to Columbia Stock Ranch creates opportunities for higher rates of deer population growth in the Columbia Stock Ranch / Deer Island subpopulation (Figure 19). For simplicity, results are shown here for the simulations in which a total of 80 deer are translocated over a two-year period. Overall, the results from a related set of scenarios featuring the translocation of 50 individuals over two years show very similar patterns.

Model results indicate that removing deer from the simulated Tennasillahe subpopulation did not adversely affect long-term demographic stability (detailed results not shown here). Only relatively modest gains are seen for the CSR / DI subpopulation under each scenario of underlying population growth, with the largest increases in median abundance at 50 years (approximately 10-15%) observed in the low-growth scenario. Abundance increases observed in the simulated CSR / DI subpopulation are not as robust as compared to other proposed metapopulation management alternatives (see Risk Analysis VI sections below), since habitat improvements in CSR / DI that are featured in other management scenarios were not implemented here. Additionally, the relatively small deer populations in neighboring subpopulation units like Sauvie – Scappoose do not contribute substantial numbers of individuals to the CSR / DI subpopulation through dispersal.

Modest gains in overall abundance are also seen at the full metapopulation scale with the basic translocation program from Tennasillahe to Columbia Stock Ranch (Figure 20). The capacity for CSR / DI subpopulation growth – with or without the infusion of individuals from the downstream Tennasillahe subpopulation – is sufficient to facilitate long-term increases in abundance. Two important factors contribute to this result. First, our model structure features dispersal to CSR / DI from the neighboring Sauvie – Scappoose subpopulation that can itself grow to large numbers under the right conditions. Secondly, the lower rates of fawn mortality at low population densities – like we see on CSR / DI – can help to promote population growth that sometimes exceeds expectations. The translocation of deer from Tennasillahe is most effective at greatly reducing the risk of CSR / DI subpopulation extinction, particularly in the very early years of the simulation when the abundance is very low.

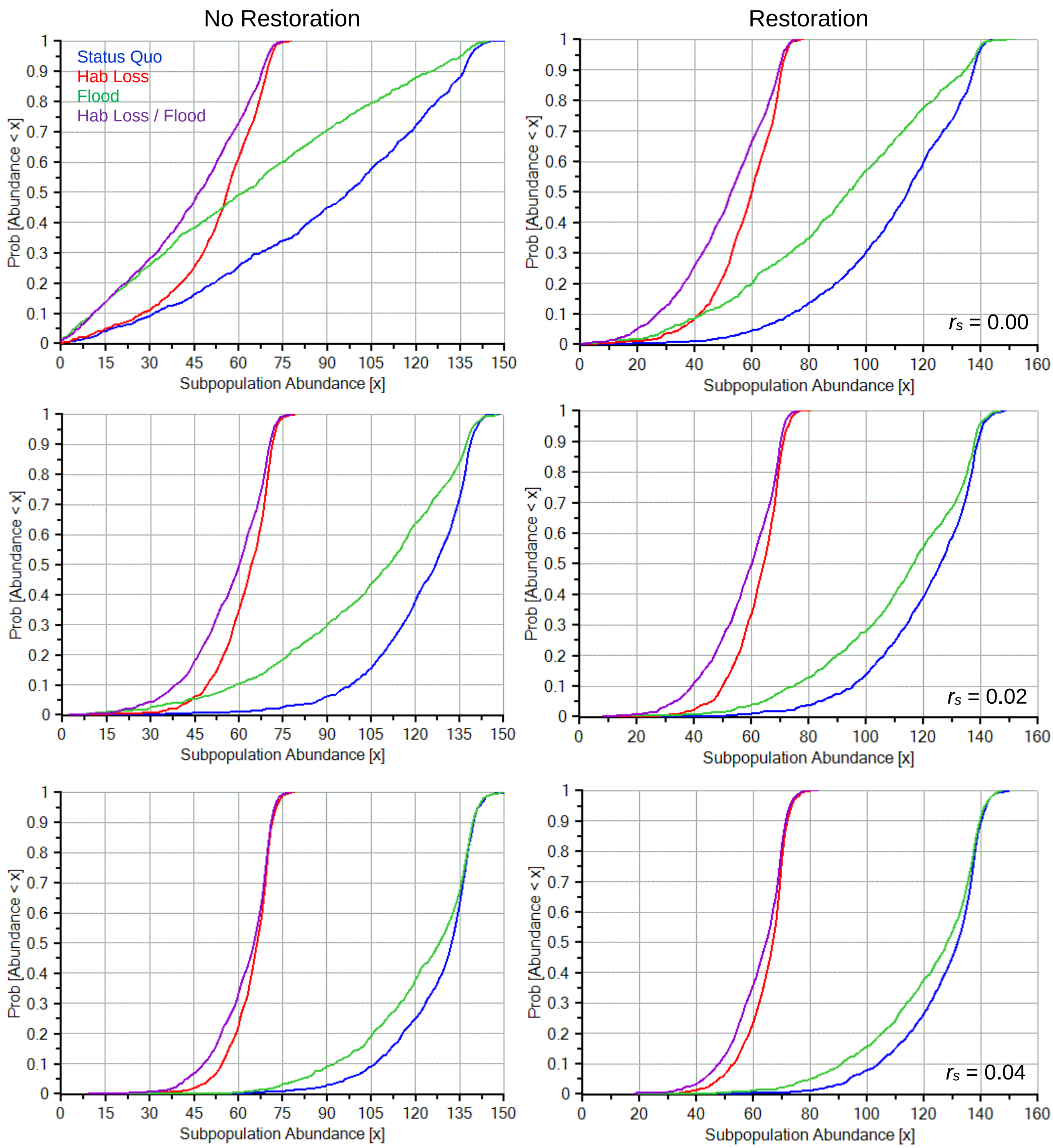


Figure 19. Quasi-extinction threshold plots at simulation year 50 for the Columbia Stock Ranch / Deer Island subpopulation, either excluding (left column) or including (right column) the proposed translocation of a total of 80 deer from Tennasillahe Island. The three rows depict alternative mean population growth rates, under the assumption of baseline dispersal rates.

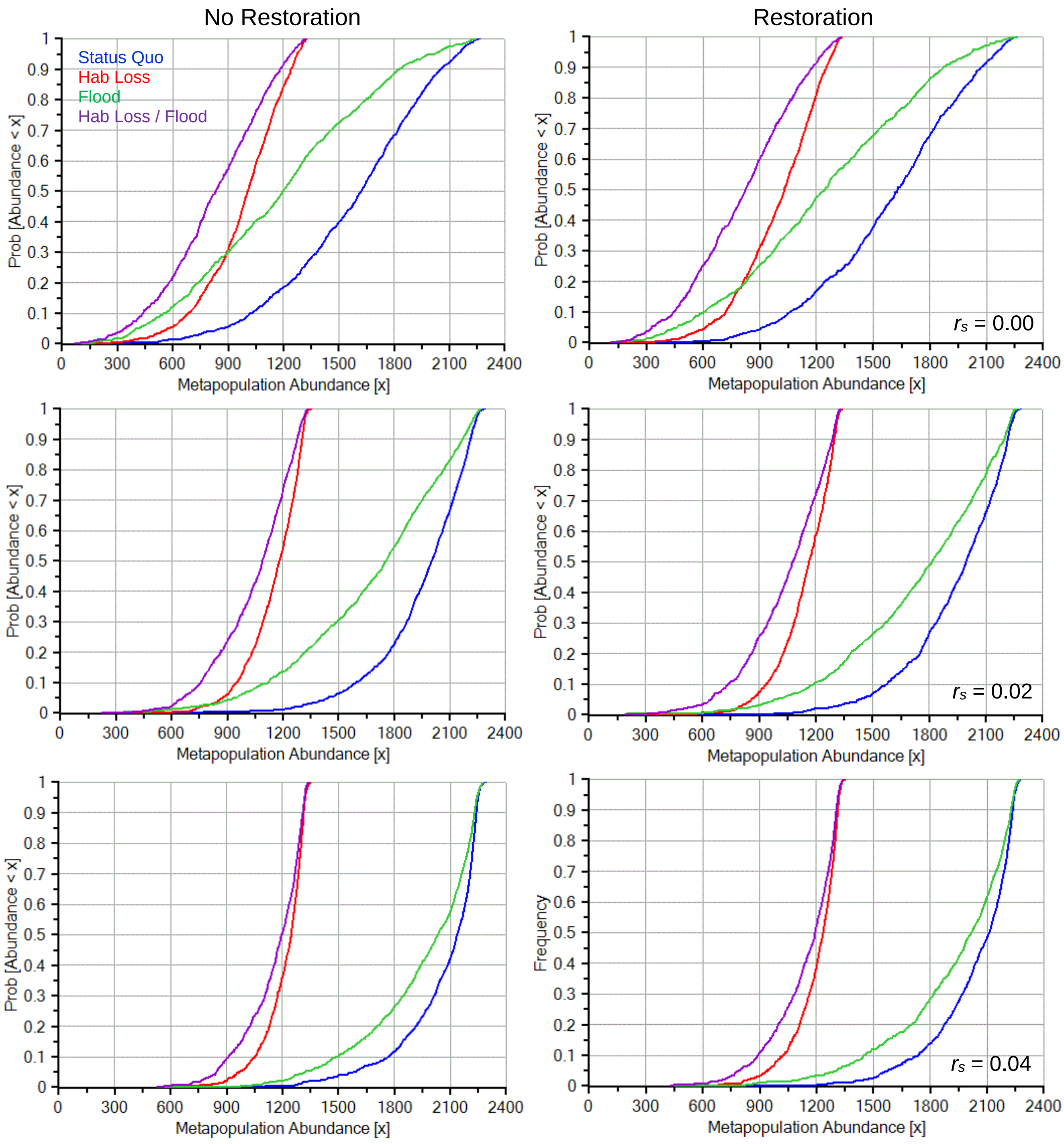


Figure 20. Quasi-extinction threshold plots at simulation year 50 for the full metapopulation, either excluding (left column) or including (right column) the proposed translocation of a total of 80 deer from Tennasillahe Island. The three rows depict alternative mean population growth rates, under the assumption of baseline dispersal rates.

Risk Analysis VIa: Deer translocation from Tennasillahe in response to salmon restoration planning (Version 1)

As expected, the rapid removal of individuals from Tennasillahe Island under the proposed salmon restoration program results in the effective extinction of that source subpopulation within 20-30 years of the program's onset (detailed results not shown here). A remnant group of less than 15 animals has a small chance of persisting for as long as 40 years on the small parcel of remaining habitat after the island's dikes are breached.

In contrast, our models suggest that the subpopulations receiving the Tennasillahe animals show marked improvements in population growth and abundance over the simulation time period analyzed here. For example, the Columbia Stock Ranch / Deer Island subpopulation (Figure 21) increases in median abundance after 50 years by approximately 10% to 25% compared to scenarios where no animals are received from Tennasillahe. The precise magnitude of the improvement depends on the specific threat scenario under consideration, and the assumed underlying long-term population growth rate. Notably, the best improvement is seen under the scenario set with the lowest mean growth rate (r_s = 0.00), where the early addition of animals provides demographic "boost" to promote population growth. Although the observed long-term abundances may approach a similar value for any pair of scenarios that differ only in the presence or absence of the proposed salmon restoration program, the early aggressive translocation of animals to Columbia Stock Ranch greatly improves the opportunity for success of that subpopulation in the first 1-2 decades after their release. This has significant implications for both demographic and genetic stability of the subpopulation.

In a similar fashion, both the Sauvie – Scappoose (Figure 22) and Westport (Figure 23) subpopulations show increased growth and overall demographic stability following the introduction of animals from Tennasillahe. Under the low-growth scenario set, median population abundances at 50 years in the Sauvie – Scappoose subpopulation increase under augmentation by as much as almost 30% in the absence of future habitat loss and flooding threats. When both habitat loss and flooding are assumed to threaten the region, translocation of deer to Sauvie results in a 25% increase in the median abundance after 50 years. The gains in population abundance are more modest in the Westport subpopulation, as that area currently supports a deer population that is much closer to its presumed ecological carrying capacity relative to the Sauvie – Scappoose subpopulation.

While gains in deer subpopulation abundance are clearly seen in the wake of the proposed translocation of animals from Tennasillahe, these gains are not seen when analyzing the overall abundance of the metapopulation (Figure 24). In fact, under the medium and high growth rate scenarios, the simulations result in a decrease in median metapopulation abundance at 50 years. This seemingly counter-intuitive result can be understood when looking at the changes in available CWTD habitat that follow from the salmon restoration program. The net gain in habitat carrying capacity through improvements on Deer Island (*K* increase = 14) and Westport (*K* increase = 75) do not make up for the loss of habitat on Tennasillahe (*K* decrease = 180). When favorable demographic conditions facilitate population growth of 2 – 4%, there simply is less habitat available under the existing proposed salmon restoration scenario, which results in lower overall metapopulation abundance predictions once translocation is implemented.

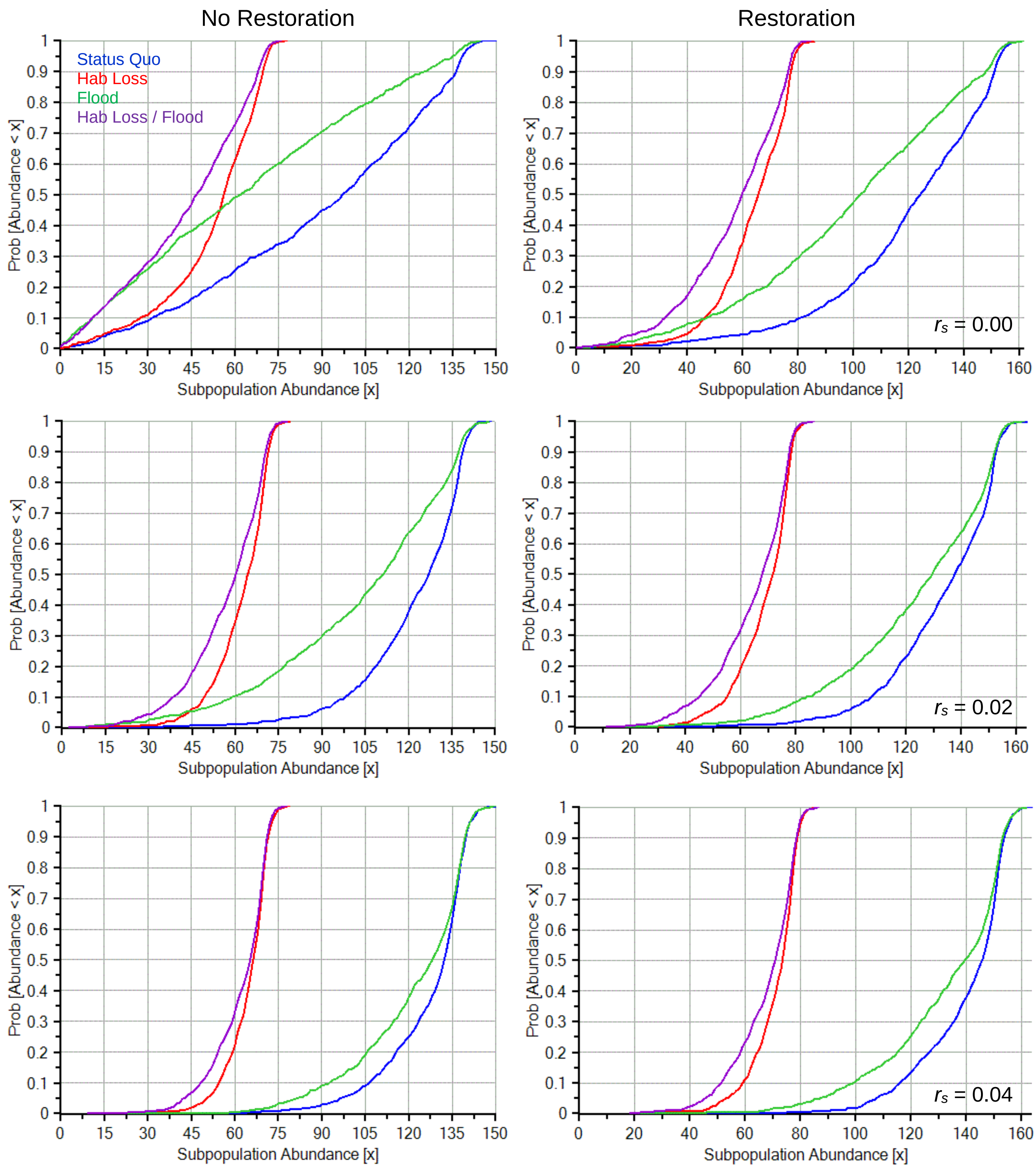


Figure 21. Quasi-extinction threshold plots at simulation year 50 for the Columbia Stock Ranch / Deer Island subpopulation, either excluding (left column) or including (right column) the proposed salmon restoration program on Tennasillahe Island. The three rows depict alternative mean population growth rates, under the assumption of baseline dispersal rates.

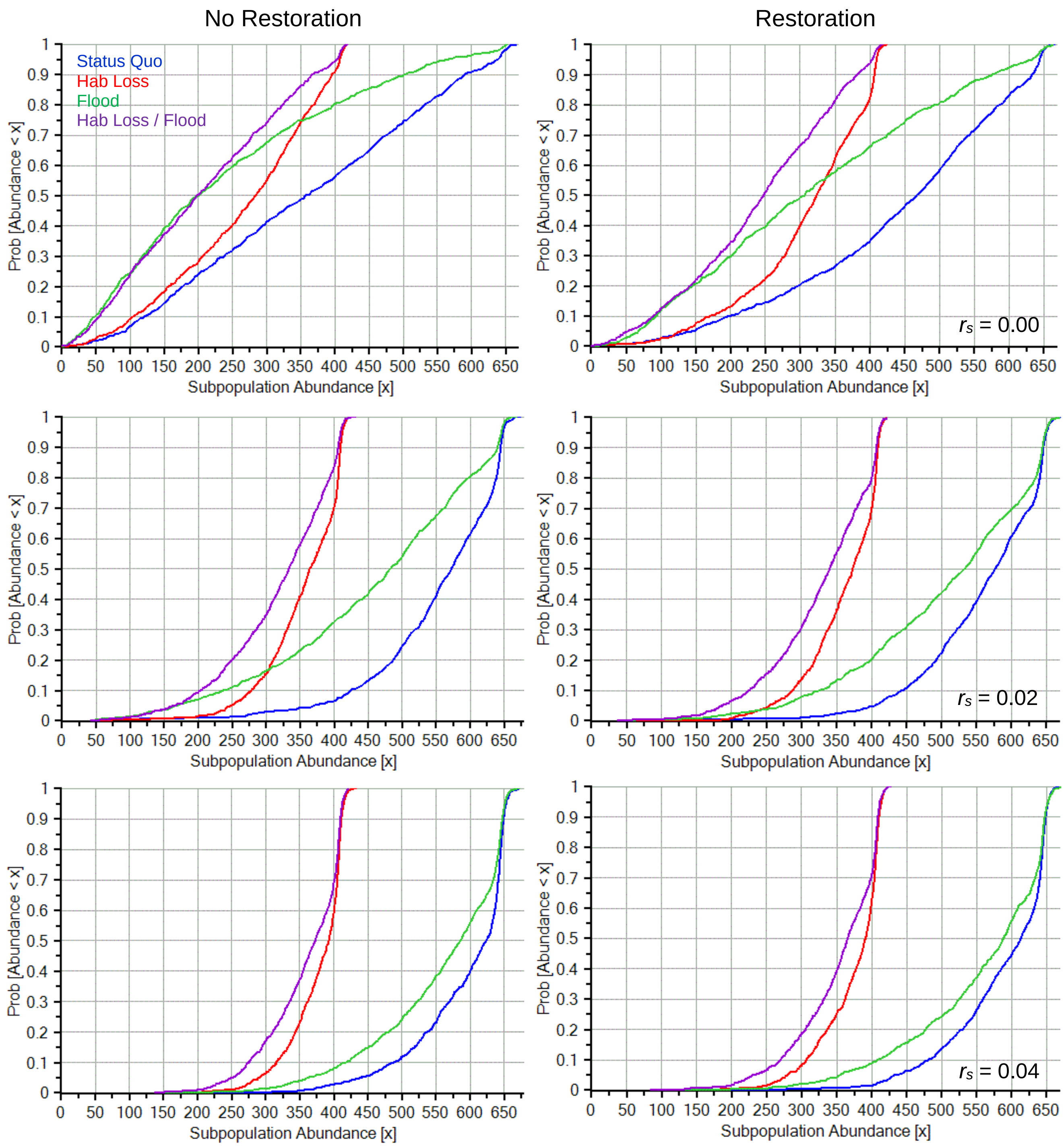


Figure 22. Quasi-extinction threshold plots at simulation year 50 for the Sauvie – Scappoose subpopulation, either excluding (left column) or including (right column) the proposed salmon restoration program on Tennasillahe Island. The three rows depict alternative mean population growth rates, under the assumption of baseline dispersal rates.

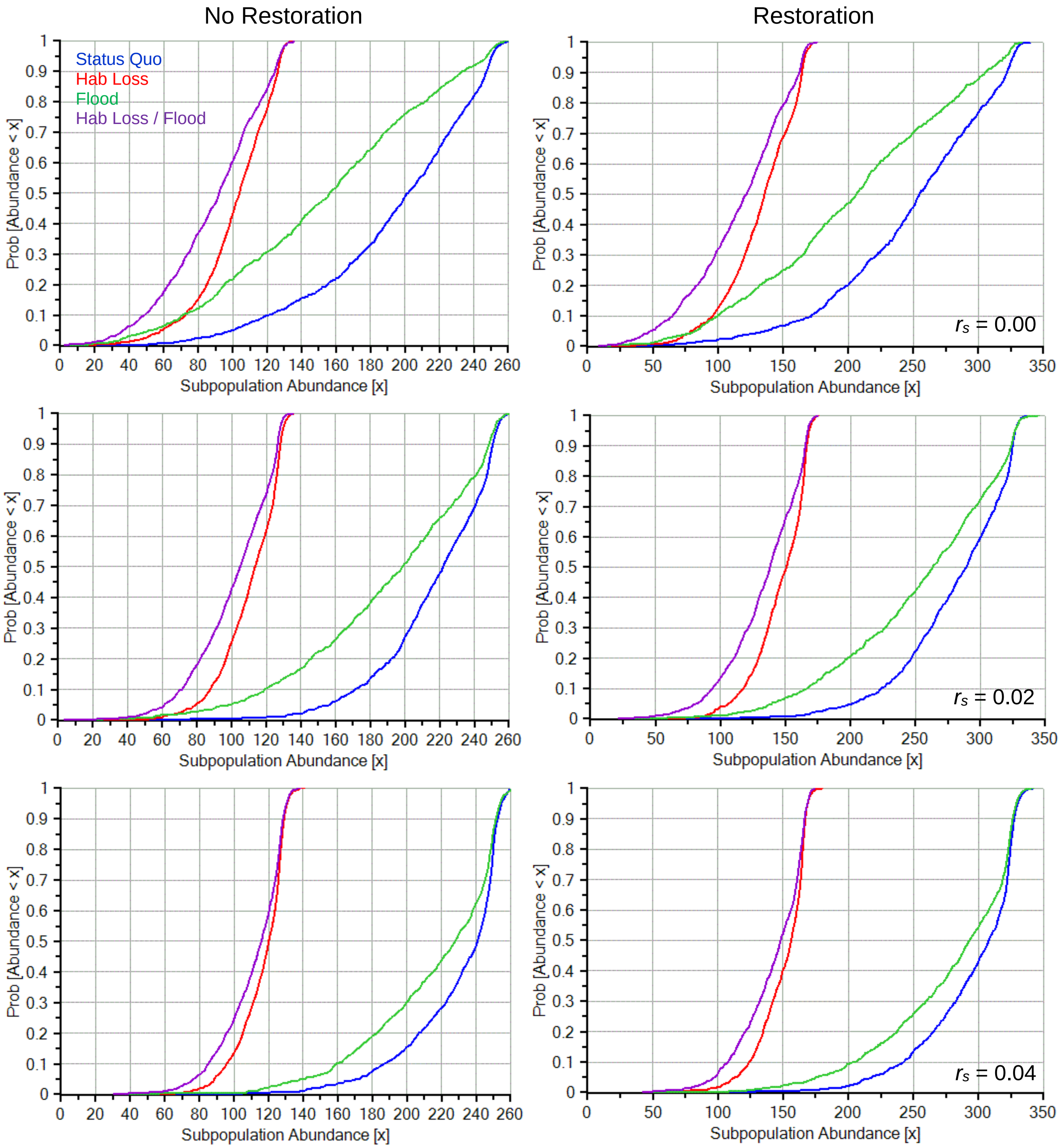


Figure 23. Quasi-extinction threshold plots at simulation year 50 for the Westport subpopulation, either excluding (left column) or including (right column) the proposed salmon restoration program on Tennasillahe Island. The three rows depict alternative mean population growth rates, under the assumption of baseline dispersal rates.

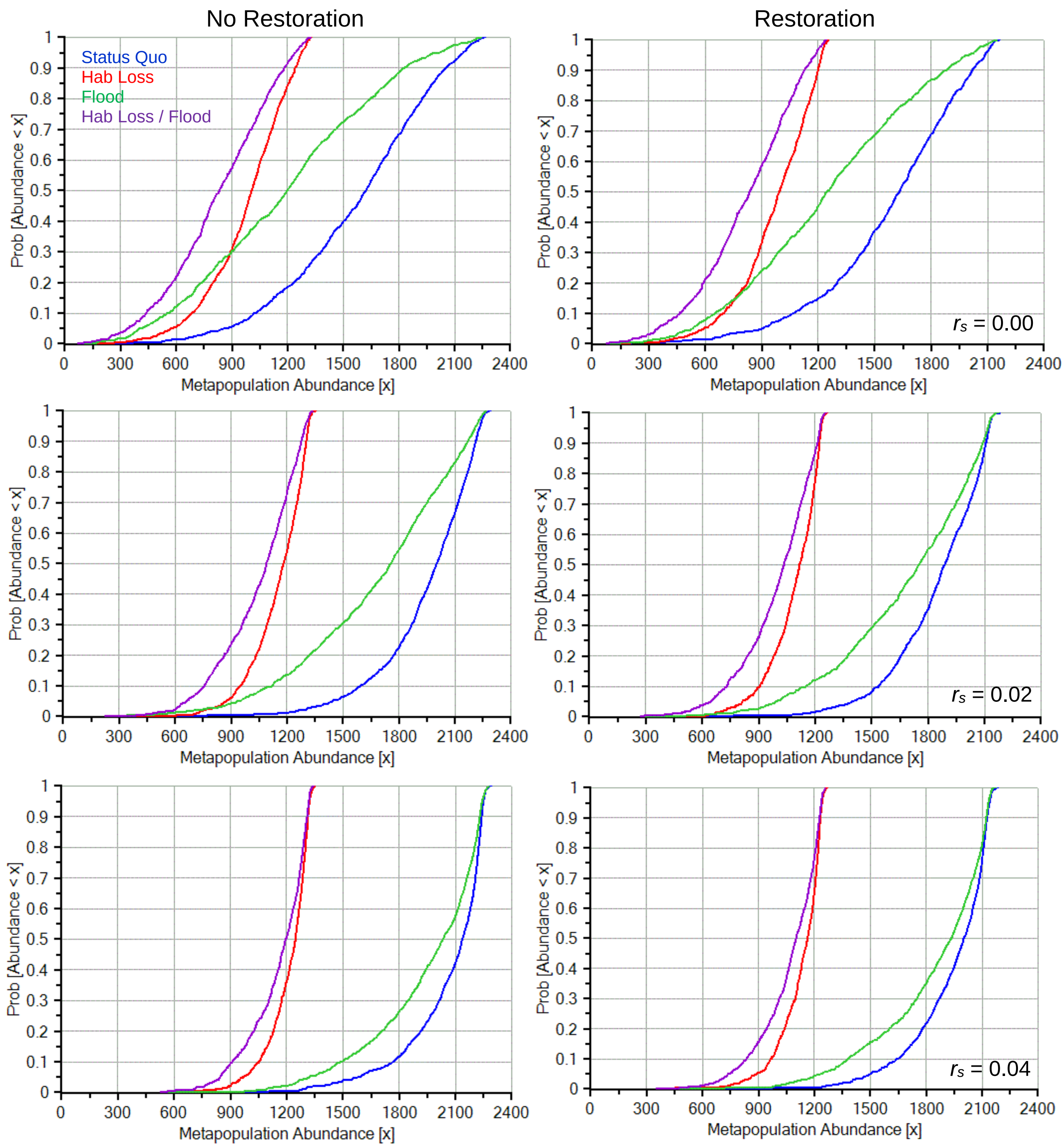


Figure 24. Quasi-extinction threshold plots at simulation year 50 for the full metapopulation, either excluding (left column) or including (right column) the proposed salmon restoration program on Tennasillahe Island. The three rows depict alternative mean population growth rates, under the assumption of baseline dispersal rates.

Risk Analysis VIb: Deer translocation from Tennasillahe in response to salmon restoration planning (Version 2)

In order to address the above concern over net habitat availability, a set of similar model scenarios were constructed in which deer removed from Tennasillahe are translocated to Columbia Stock Ranch and Westport as before, but now the Sauvie habitat has been replaced as a recipient with the habitat area near the East Fork of the Lewis River. This area of approximately 2000 acres of mostly county-owned land is 5 miles to the east of the northern reaches of the Ridgefield subpopulation, and has been identified as another habitat candidate for establishing a CWTD subpopulation. Based on the method for estimating carrying capacity already described previously, we assume a carrying capacity for this area of about 400 individuals. The translocation models assume approximately 25 individuals (18 females, 13 adults; 7 males, 4 adults) are released each year in model years 7 and 8, after translocations to Columbia Stock Ranch and Westport have been implemented. Furthermore, we assume some low level of connectivity to the Ridgefield habitat to the west, which is included in our model as a symmetric 0.5% dispersal rate to and from this neighboring subpopulation.

The demographic dynamics of the source Tennasillahe subpopulation and the recipient Columbia Stock Ranch / Deer Island and Westport subpopulations under these alternative translocation scenarios are essentially unchanged from the scenarios discussed above and depicted in Figures 19 and 20. Under the low-growth scenario, the median abundance of the new East Fork Lewis River subpopulation is about 190 animals after 50 years (Figure 25). Note, however, that the Figure shows a substantial risk of this subpopulation remaining small over time despite the initial introduction attempt. The probability of being unsuccessful in establishing a functional subpopulation under the low-growth scenario is approximately 5 – 7% at 50 years. [Note that this value is higher than that displayed in the upper-left panel of Figure 25, which shows the risk of the subpopulation being below a given abundance at 50 years regardless of the identification of the sex of the individuals.] This risk decreases substantially under the higher growth scenarios, as does the median expected abundance at that point in the future.

More importantly, the expected metapopulation abundance improves consistently when translocation includes a larger source population like the East Fork Lewis River habitat (Figure 26). Moreover, the magnitude of the improvement is greater under the higher growth rate scenarios, where the East Fork Lewis River subpopulation is capable of growing to the larger size consistent with the estimated habitat carrying capacity of about 400 deer. At the full metapopulation level, therefore, the use of this larger habitat area appears to be a more desirable alternative as it facilitates improved metapopulation growth and stability.

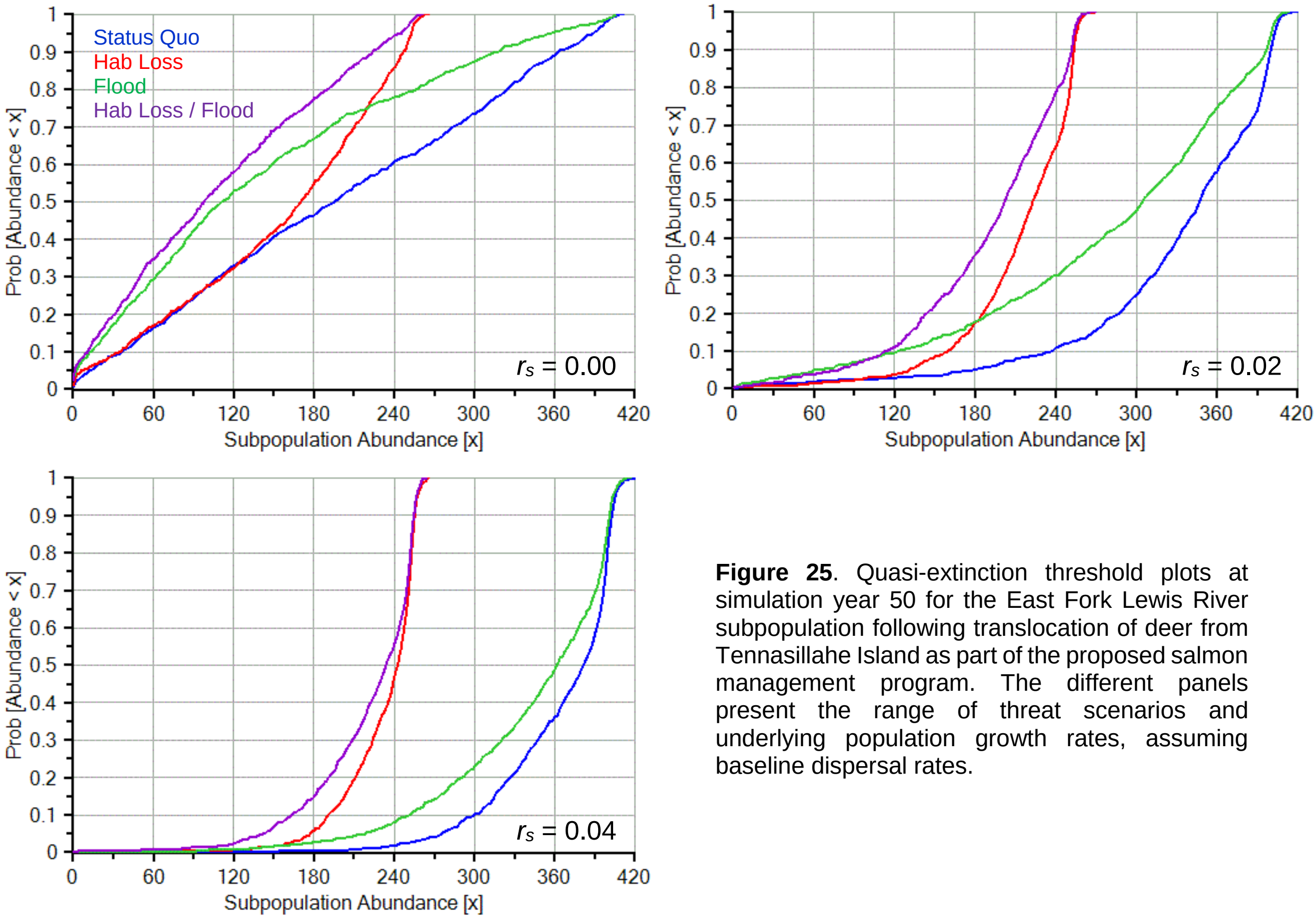


Figure 25. Quasi-extinction threshold plots at simulation year 50 for the East Fork Lewis River subpopulation following translocation of deer from Tennasillahe Island as part of the proposed salmon management program. The different panels present the range of threat scenarios and underlying population growth rates, assuming baseline dispersal rates.

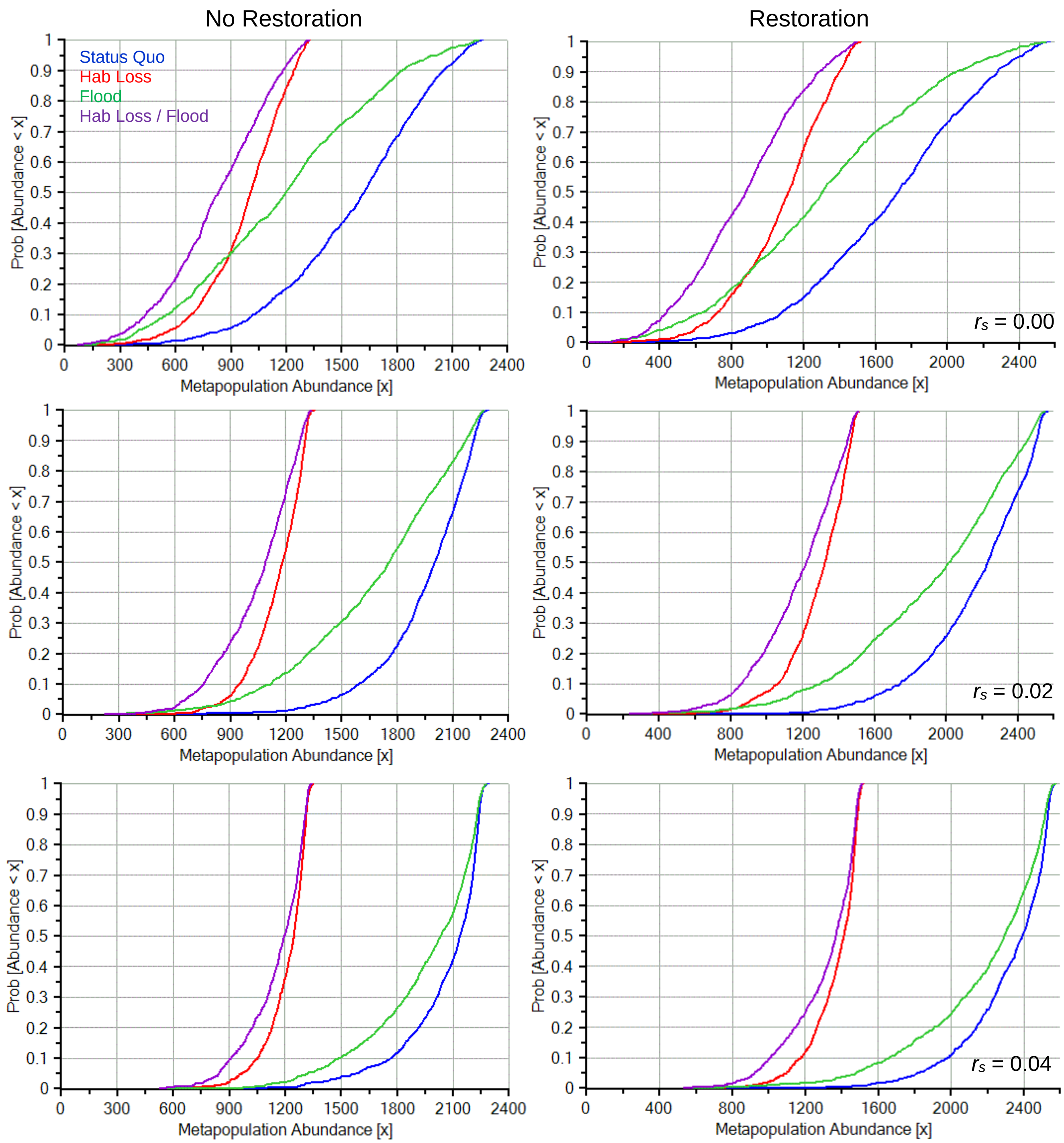


Figure 26. Quasi-extinction threshold plots at simulation year 50 for the full metapopulation, either excluding (left column) or including (right column) the proposed salmon restoration program on Tennasillahe Island and using the East Fork Lewis River habitat as a source instead of the Sauvie – Scappoose subpopulation. The three rows depict alternative mean population growth rates, under the assumption of baseline dispersal rates.

Risk Analysis VII: Targeted habitat management in Group B subpopulations

Figures 27 – 29 show 100-year persistence probability trajectories (the opposite of extinction risk curves) for the Group B subpopulations (Willow Grove – Fisher / Hump, Lord / Walker / Dibblee, and Wasser – Winter / Kalama, respectively) under the incremental increases in subpopulation-specific carrying capacity (*K*) brought about through dedicated habitat management in those areas. Across all Group B subpopulations, the Figures show that the persistence probability is affected to the greatest degree by the combined predicted impacts of prolonged habitat loss and increased flooding risk. This is seen most clearly in the Lord / Walker / Dibblee and Wasser – Winter / Kalama subpopulations, where the final probability of long-term persistence over 100 years drops to about 0.7. It is worth noting that this reduction in persistence probability does not become apparent for more than 40-50 years after the beginning of the simulations. This lag is likely due to the combined impacts of accumulated inbreeding depression and the negative impacts of demographic stochasticity on chronically small populations. Active habitat management designed to increase local carrying capacity, under the conditions simulated in this analysis, is shown to be highly effective in reducing the risk of subpopulation extinction and, therefore, improving the long-range prospects for persistence.

The increases in habitat carrying capacity – even relatively modest increases of just 25% of the starting value – can result in larger subpopulation abundances and, therefore, lower levels of inbreeding and greater demographic stability. Another significant benefit of this management activity can be seen in the extent of demographic connectivity among these Group B subpopulations, and their connectivity to the wider metapopulation. As these subpopulations grow into expanded habitats, the total number of individuals dispersing among neighboring Group B subpopulations increases – even as the probability (rate) of dispersal remains constant (Figure 30A). In addition, and through the same mechanism, connectivity to subpopulations outside of Group B increases with dedicated habitat management in this vital linkage area (Figure 30B). As a consequence of this improved metapopulation functionality, retention of genetic diversity within and among Group B subpopulations increases, as does overall metapopulation stability (specific results not shown here).

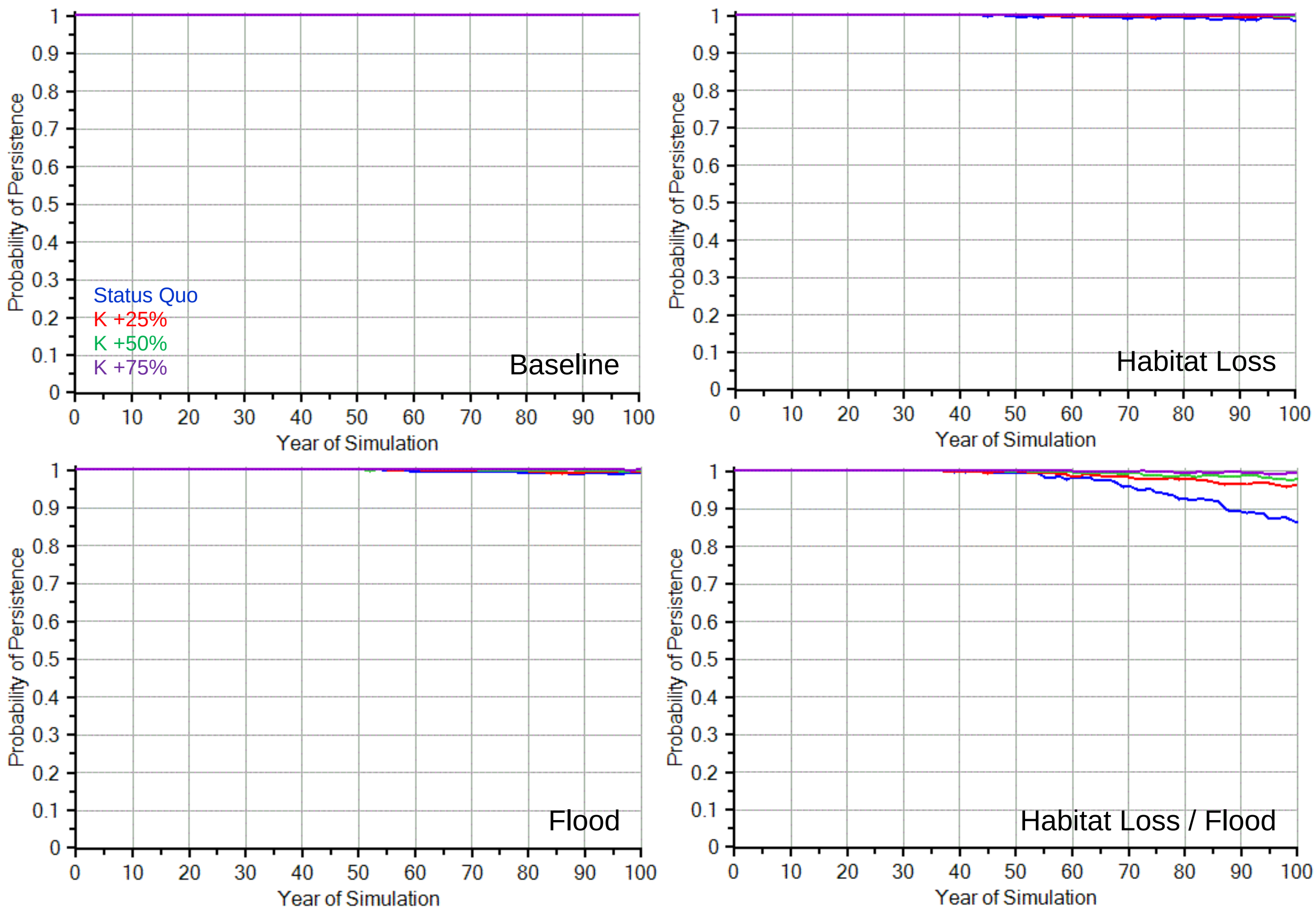


Figure 27. Probability of persistence over 100 years for the Willow Grove – Fisher / Hump subpopulation, under the standard set of threat scenarios and assuming different levels of habitat management leading to proportional increases in habitat carrying capacity, *K*.

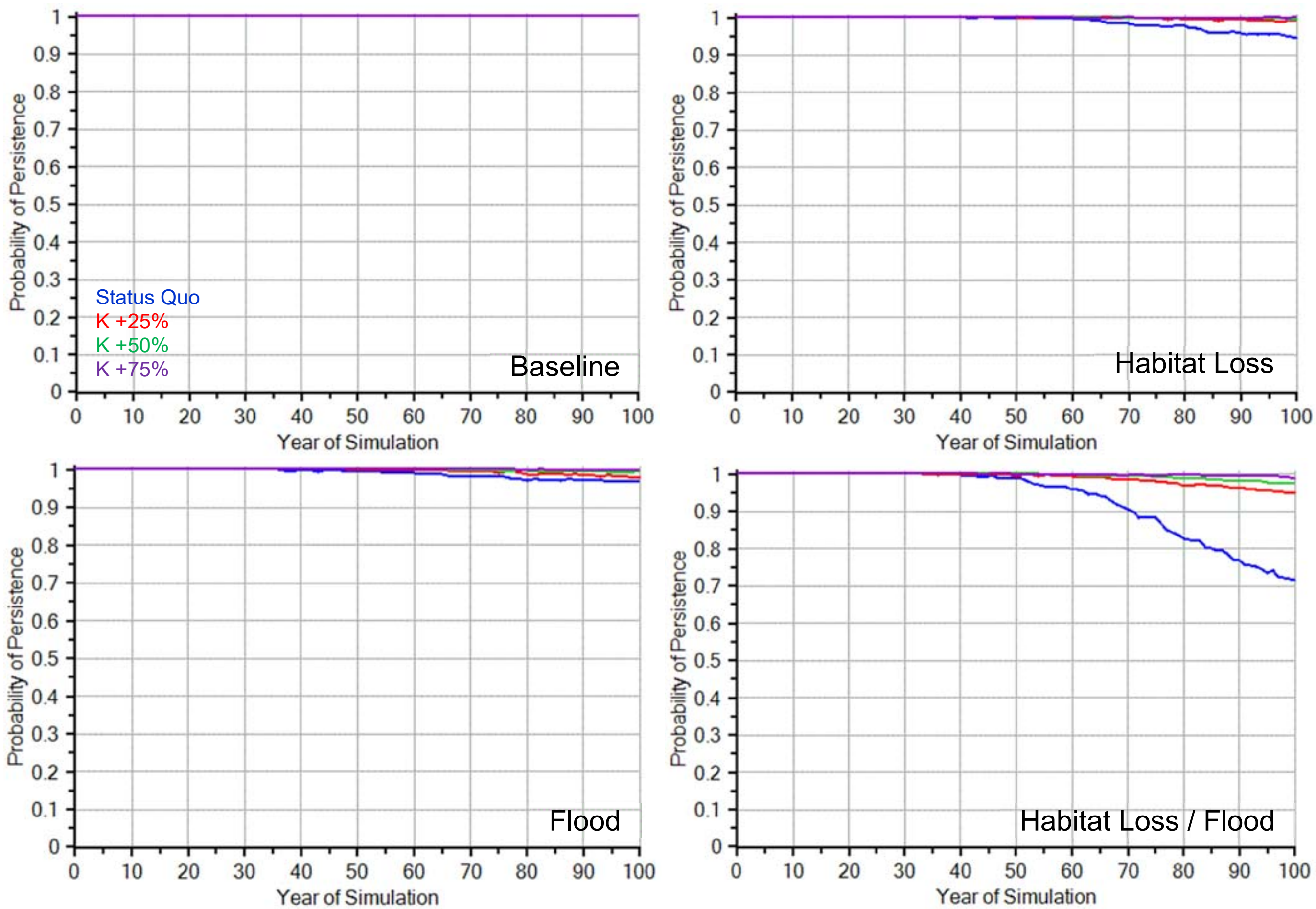


Figure 28. Probability of persistence over 100 years for the Lord / Walker / Dibblee subpopulation, under the standard set of threat scenarios and assuming different levels of habitat management leading to proportional increases in habitat carrying capacity, *K*.

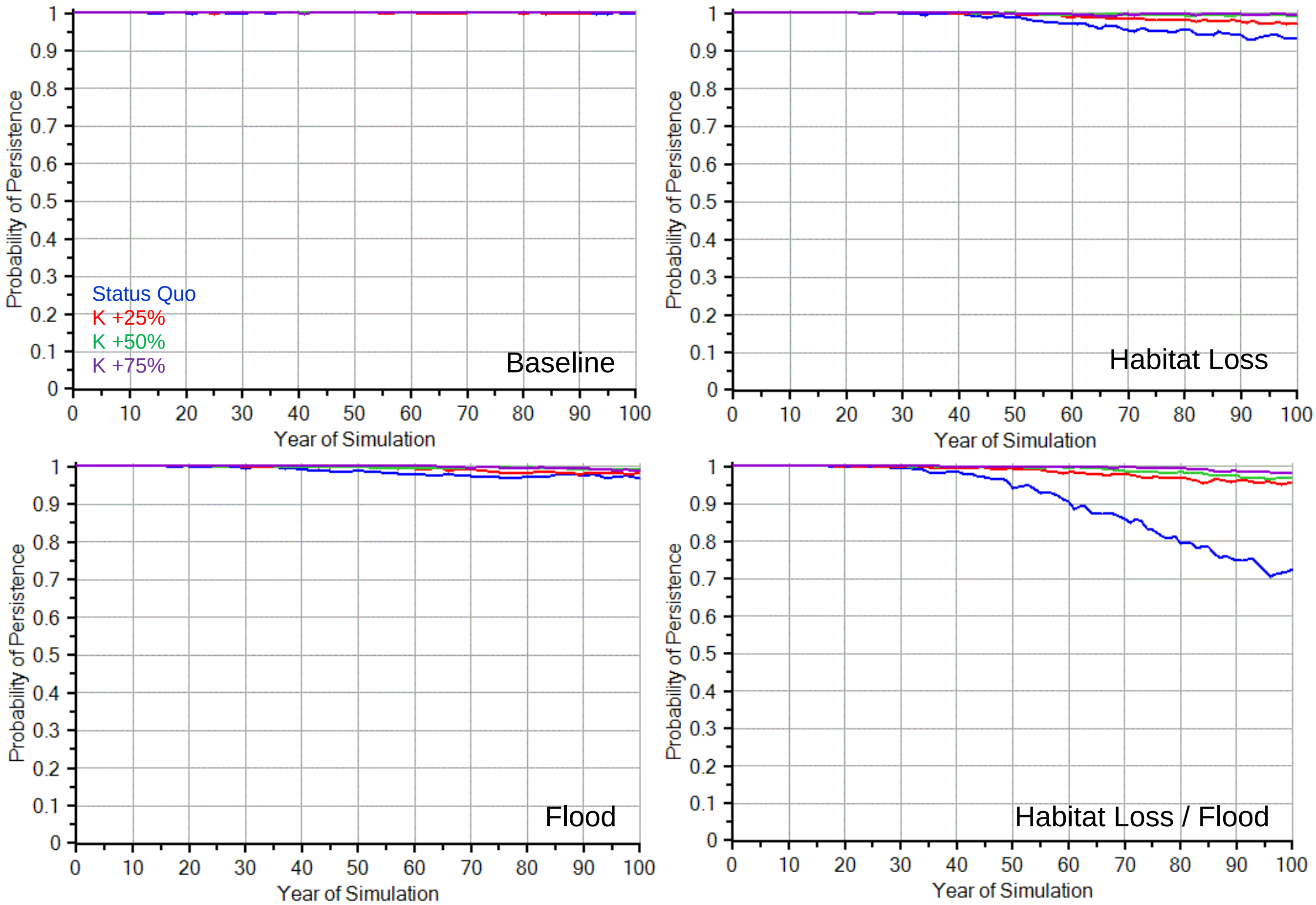


Figure 29. Probability of persistence over 100 years for the Wasser – Winter / Kalama subpopulation, under the standard set of threat scenarios and assuming different levels of habitat management leading to proportional increases in habitat carrying capacity, *K*.

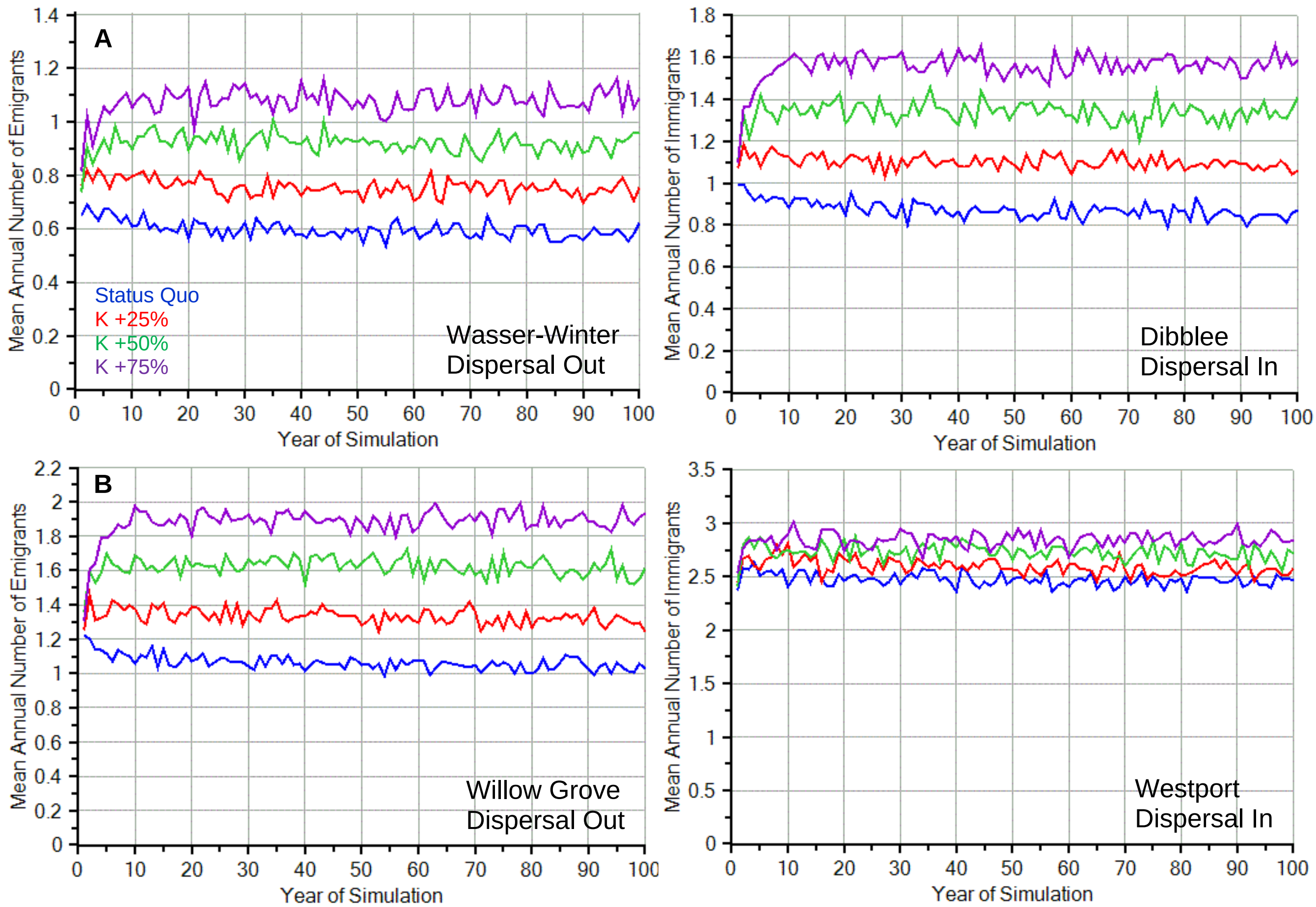


Figure 30. Dispersal dynamics in selected subpopulations as a function of the extent of habitat improvements in Group B subpopulations that lead to increased habitat carrying capacities (*K*). (A), emigration out of Wasser – Winter / Kalama and simultaneous immigration into the neighboring downstream Lord / Walker / Dibblee subpopulation. (B), emigration out of Willow Grove – Fisher / Hump and simultaneous immigration into the downstream neighboring Group A Westport – Crims subpopulation. All simulations assume a Status Quo environmental condition (i.e., no future threats from habitat loss or increased flooding risk) and an underlying mean expected annual subpopulation growth rate of 0.02.

Conclusions

The following is a summary of the important conclusions to be drawn from this analysis.

1. In consultation with experts on the subspecies' biology, ecology and management, we were able to create a realistic simulation of Columbian white-tailed deer demographic dynamics across the ten subpopulations that comprise the Columbia River DPS. This simulation can therefore be used as a tool to evaluate future subpopulation dynamics under a range of alternative scenarios that represent the action of various threats to CWTD habitat and survival.
2. A synthesis of data on current subpopulation abundance (as of January 2018, in the midst of the PVA phase of this project) revealed that 55.3% of the deer comprising this DPS (677 of 1224) reside in subpopulations on private lands (Puget Island, Westport – Crims, Lord / Walker / Dibblee, Willow Grove – Fisher / Hump, Wasser – Winter / Kalama, and Columbia Stock Ranch / Deer Island). Moreover, 70% of the deer (856 of 1224) are concentrated in the farthest downstream Group A subpopulations.
3. Demographic sensitivity analysis indicates that the stochastic population growth rate is most strongly influenced by adult female survival. However, taking into account our ability to derive estimates of a suite of demographic parameters used in PVA model input, it is apparent that annual fawn survival is the greatest contributor to our uncertainty in estimating future rates of subpopulation growth. This is partly explained by the assumption that we have greater confidence in our estimates of annual adult female survival. Other important factors contributing to variance in subpopulation growth include the severity of inbreeding depression and the frequency of severe flooding events that impact survivorship across all age classes.
4. Inbreeding depression may be a significant factor influencing the viability of the smaller populations (all Group B subpopulations, as well as CSR / DI and Sauvie – Scappoose in Group C). While genetic data suggest the presence of inbreeding in CWTD subpopulations, the demographic consequences of this process remain unknown. Additional field-based study of these impacts may help to inform future management of these at-risk subpopulations.
5. The extent of demographic connectivity between neighboring subpopulations (probabilistic exchange of young deer, predominantly yearling bucks) is an important factor determining future viability of smaller subpopulations that may not have the intrinsic capacity to grow on their own.
6. A simple analysis of data on recent trends in CWTD abundance during the period 1995 – 2005 across the occupied subpopulation units (Puget Island, Tennasillahe Island, Westport / Wallace Island, JBH Mainland Unit) (USFWS 2013) reveals an annual rate of total population decline that approaches 4% over the period when relatively more consistently reliable monitoring methods were employed through time. The beginning of this time interval for analysis was chosen to roughly coincide with the presumed return of the JBH Mainland Unit population to a more sustainable abundance following severe overpopulation of the area, far beyond the habitat's long-term carrying capacity. This PVA, informed by recent threats analysis provided by State and Federal authorities in their recovery plan evaluations (USFWS 2013, Azerrad 2016), identified a suite of threats that are likely contributors to the observed metapopulation decline in recent decades.
7. A set of model scenarios were developed that described alternative rates of potential future subpopulation growth: low growth, with a long-term mean growth rate $r_s \approx 0.00$; medium growth, with a long-term mean growth rate $r_s \approx 0.02$; and high growth, with a long-term mean growth rate $r_s \approx 0.04$. These scenarios are based on an assumed response to broad threat mitigation activities, primarily in the form of predator (coyote) control that would result in corresponding changes in fawn survival. These model growth rates represent a substantial improvement over the mean

metapopulation declines for the Columbia River DPS described above, yet they are also well within the range of growth rates considered feasible for the species (e.g., Chitwood 2015).

8. Our scenarios including future threats from increased habitat loss and severe flooding events should be considered exploratory in the absence of detailed evidence of the mechanistic relationship between these threats and their impacts on CWTD demography and ecology. Nevertheless, the models are valuable in their ability to assess various plausible “what-if” scenarios of future conditions in the DPS and the potential impacts of these events.

9. Predator (coyote) removal, assumed to result in increased fawn survival rates, can buffer CWTD subpopulations against the impacts of more frequent severe flooding events through stronger annual subpopulation growth. However, this cannot similarly buffer a subpopulation against the negative impacts of habitat loss, i.e., a decline in subpopulation carrying capacity.

10. The smaller Group B subpopulations (Willow Grove – Fisher / Hump, Lord / Walker / Dibblee and Wasser – Winter / Kalama) are typically not able to maintain population abundances above the $N = 50$ viability threshold, and therefore may not be able to contribute significantly to overall metapopulation viability and recovery if no additional habitat is acquired. This conclusion is influenced strongly by the specification of subpopulation-specific carrying capacities that limit future increases in abundance.

11. The Sauvie – Scappoose subpopulation is currently rather small ($N = 40$), but could grow to a considerable size if fawn mortality is managed and subpopulation growth rates are increased. This is a result of the large estimated habitat carrying capacity for this subpopulation.

12. If mean annual growth rates across the subpopulations comprising the Columbia River DPS consistently exceed 2%, the PVA described here suggests that the probability of the DPS exceeding the current viability threshold of $N = 400$ after 50 years is very high – over 97%. This model prediction takes into account the possible future imposition of increased frequency of significant flooding and increased rates of overall habitat loss in currently occupied lands. If higher rates of coyote predation lead to lower fawn survival, such that an individual subpopulation can only maintain its future abundance at current levels ($r_s = 0.0$), and if both habitat loss and an increase in the frequency of severe flood events becomes a reality, at the rates specified in this analysis, there is a small but enhanced risk (probability = 0.075) that the metapopulation abundance may not exceed the viability threshold of $N = 400$ after 50 years.

13. Translocation of deer from Tennasillahe to the Columbia Stock Ranch as a mechanism to reduce source population density, as simulated in this PVA, can significantly reduce short-term risks of population declines and/or extinction in the CSR / DI subpopulation. However, this improvement does not come without some added risk to the source population – particularly if we assume an increase in future threats from flooding and broad-scale habitat loss.

14. Salmon restoration in the lower reaches of the Columbia River may include significant modification of Tennasillahe Island to expand the extent of suitable salmon spawning habitat. In response to this proposed effort, translocation of deer from Tennasillahe to the Columbia Stock Ranch and the Sauvie – Scappoose and Westport – Crims subpopulations, as simulated in this PVA, results in a high likelihood of extinction of the source population on Tennasillahe. However, the translocation leads to significant improvements in deer abundance in the CSR / DI and Sauvie – Scappoose subpopulations, with more modest improvements in the Westport subpopulation (less opportunity for significant population growth there). If salmon restoration takes place, and if no new additional habitat is acquired, the cumulative reduction in habitat availability, coupled with the nearly complete loss of Tennasillahe, leads to overall declines in metapopulation abundance. This is particularly evident when the risk of future habitat loss –

independent of the loss of Tennasillahe habitat through the proposed salmon restoration effort – is included in the simulations.

15. If the aforementioned salmon restoration program and associated CWTD translocation effort featured movement of a group of deer to the relatively large parcel of habitat near the East Fork Lewis River, there would be a net gain in available habitat following the loss of the Tennasillahe area and an associated positive change to metapopulation carrying capacity. Our models predict that this would result, given demographic conditions that facilitate long-term population growth, in increased metapopulation abundance over a comparable scenario where the salmon restoration program were not implemented.
16. Habitat management among Group B subpopulations as simulated in this PVA, with the goal of increasing CWTD carrying capacity in these areas, can significantly improve long-term subpopulation viability through increasing deer abundance. More importantly, the analysis demonstrates a modest but important improvement to overall metapopulation function through increased dispersal of deer among Group B subpopulations and to neighboring Group A and C subpopulations, thereby improving demographic and (likely more importantly) genetic structure across the metapopulation.
17. Future viability analyses could be greatly improved if additional data were collected from field studies targeting the following processes: (i) inter-subpopulation dispersal, (ii) predicted future rates of habitat loss, (iii) flooding impacts.

<u>Implications of This Analysis for CWTD Recovery Planning</u>

These summary points give critical information that is key to addressing a key question posed by the USFWS 5-Year Review of this program (USFWS 2013) (and repeated on page 6 of this report), namely "…whether the overall population, minimum secure subpopulations, and distribution of the deer within the subpopulations are still adequate to achieve recovery." In order to provide guidance on this question, we must first refer to the recovery criteria as stated in the Columbian White-Tailed Deer Recovery Plan (USFWS 1983). To downlist the Columbia River DPS from Endangered to Threatened, the following conditions must be met:

<u>Criterion 1: Abundance</u>

Maintain a minimum of at least 400 CWTD across the Columbia River DPS

<u>Criterion 2: Distribution</u>

Maintain three viable subpopulations, two of which are located on secure habitat.

- Definition of Viable: A minimum November population of 50 individuals or more.
- Definition of Secure Habitat: Free from adverse human activities in the foreseeable future and relatively safe from natural phenomena that would destroy its value to the CWTD. Habitat may be secured through means such as purchase, easements, leases, conservation agreements, landowner incentives, memorandums of understanding, and local land use planning or zoning ordinances.

Based on the explicit recovery criteria as they are laid out above, and on a detailed evaluation of subpopulation status as presented in the USFWS 5-Year Review, it is logical to conclude that both of these criteria have been met as of the date of preparation of that document, and that the Columbia River DPS could be considered as a legitimate candidate for downlisting. More information supporting this conclusion is in the USFWS 5-Year Review, which ultimately concludes that the DPS should indeed be downlisted to Threatened. However, the many insights gained from the analyses and the subsequent discussions at both the PVA and PHVA workshops suggest that the recovery criteria as currently written in the 1983 Recovery Plan and reproduced in subsequent documents do not adequately describe the demographic and ecological conditions that would be consistent with long-term viability of the Columbia River DPS. The discussion below presents an argument for why the current criteria are insufficient, and provides suggestions for revising the criteria to generate a more informed description of the conditions necessary for long-term viability and recovery of the DPS.

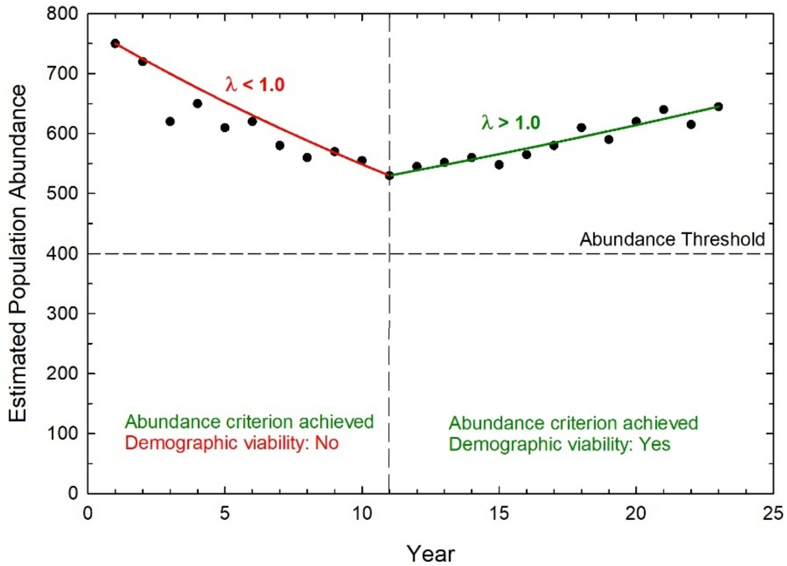
First, let us consider the "overall population" as labeled in the longer quotation in the 5-Year Review statement reproduced above. We can consider historic data on subpopulation abundance and the trends in those abundance data over time. Table 6 reproduces a portion of subpopulation abundance data included in the USFWS 5-Year Review (USFWS 2013: Table 2). The time period 1995 – 2005 was chosen for analysis for two reasons: (i) the very high density of deer on the JBH Mainland Unit since the late 1980s had declined to a more sustainable level, representing a more natural state for the population in that habitat; and (ii) population survey methods changed in 2006, and abundance estimates for the various subpopulations became unavailable in subsequent years for a variety of reasons. In other words, the chosen time interval represents a period where all subpopulations were experiencing reasonable demographic dynamics and were consistently surveyed using the same methodology. Inspection of the annual changes in deer abundance across the DPS during this time period, including the new subpopulations created on the Upper Estuary Islands beginning in 1999, shows that while the total abundance across the DPS ranged from 545 to 750 deer – well above the abundance criteria of 400 deemed diagnostic of recovery – that total population abundance declined at a mean annual rate of approximately 2.4%.

Table 6. Estimated abundance of Columbian white-tailed deer subpopulations comprising the Columbia River DPS. Data reproduced from USFWS (2013).

Year	Puget Island	Tenasillahe Island	Westport/ Wallace Island	JBH Mainland Unit	Upper Estuary Islands[c]	Ridgefield NWR	Total
1995	200	205	225	120	0		750
1996	200	125	225	60	0		610
1997	200	150	200	100	0		650
1998	200	200	200	110	0		710
1999	150	160	140	110	25		585
2000	150	135	150	120	55		610
2001	125	135	150	120	55		585
2002	125	100	140	125	55		545
2003	125	100	140	115	80		560
2004	110	100	140	110	95		555
2005	125	100	140	100	100		565

Although we do not have consistent and fully reliable annual estimates of abundance for each extant subpopulation over the past 10-15 years, we do know that abundance across the DPS has increased substantially from the time period discussed above. Nevertheless, the analysis of historic data described above illustrates an important point about potential problems with relying solely on simple abundance data to measure population viability. A wildlife metapopulation that substantially exceeds a stated abundance threshold, but is also declining at a steady rate over an extended period of time, cannot reasonably be considered viable and on its way to recovery (see Figure 31). Therefore, an additional criterion is desired that includes some statement about the need for sustained positive population growth over an appropriate timeframe.

Figure 31. Stylized population trajectory illustrating the relationship between estimated population abundance and trends in that abundance over time in the context of evaluating potential for recovery. Abundance threshold of N = 400 is taken from the 1983 CWTD Recovery Plan, while abundance data are for illustrative purposes only.



Second, let us address the issue of “minimum secure subpopulations” as the second component of the statement above. According to Criterion 2, a viable population is defined by a November abundance estimate of at least 50 individuals. The 1983 Recovery Plan (Appendix A) states that the derivation of this threshold abundance is based on population genetic considerations, namely, avoidance of unacceptable levels of inbreeding. A related metric that can be used to describe population genetic viability is the extent of retention of gene diversity (GD), also known as expected heterozygosity (Lacy 1995). Retention of gene diversity is directly related to population abundance, with smaller populations losing GD at a more rapid rate than their larger counterparts. Managers of captive populations of endangered species typically adopt a threshold of retaining no less than 90% of the gene diversity sampled from the wild to initiate that captive population. We can adopt a similar threshold to evaluate the capacity for different CWTD subpopulations within the DPS to maintain population genetic viability in addition to the traditional abundance criterion currently stated in the Recovery Plan.

Table 7 shows results from simulations that assume a mean expected annual subpopulation growth rate of 0.02, and no future increase in current threats to population demographics, i.e., the Status Quo conditions described in other scenarios in this report. The results are for selected smaller Group B subpopulations, in which mean predicted abundance is near the stated threshold of 50 individuals needed for subpopulation viability. When provided with the opportunity for positive population growth, and with normal dispersal dynamics as constructed in our simulations, both the Willow Grove – Fisher / Hump and Lord / Walker / Dibblee subpopulations maintain an abundance of more than 50 individuals for 50 years (see table entries with green shading). However, if dispersal is eliminated from the simulations, the Willow Grove – Fisher / Hump subpopulation does not reach the desired abundance over that time period. Additionally, gene diversity in that subpopulation is adequately maintained when demographically connected to its nearest neighbors, whereas demographic isolation leads to higher levels of inbreeding and resulting greater loss of gene diversity over time. The larger Lord / Walker / Dibblee maintains the desired abundance even when demographically isolated, but also requires connectivity with its neighbors to maintain adequate levels of gene diversity over a 50-year period.

Table 7. Simulation results from selected Group B subpopulations in model scenarios including the standard set of threats and assuming a mean expected annual subpopulation growth rate of 0.02. N_{50}, mean subpopulation abundance at simulation year 50; $Pr[N_{50}<50]$, probability that the mean subpopulation abundance at simulation year 50 is less than 50 individuals; GD_{50} and GD_{100}, mean gene diversity retained in the subpopulation relative to the start of the simulation at years 50 and 100, respectively. Table entries with green shading indicate conditions where either existing abundance criteria (N>50) or proposed genetic criteria (GD_x > 0.90) are satisfied. See text for additional details.

Subpopulation	N_{50}	$Pr[N_{50}<50]$	GD_{50}	GD_{100}
Willow Grove – Fisher / Hump (*K* = 61)				
Isolated	47.7	0.533	0.808	0.645
Connected	52.5	0.357	0.936	0.913
Lord / Walker / Dibblee (*K* = 81)				
Isolated	65.5	0.148	0.855	0.732
Connected	67.3	0.107	0.902	0.865

The pattern of gene diversity retention revealed in Table 7 is in reality rather complicated, as the future extent of GD retention in specific subpopulations is also a function of dispersal that leads to a net inflow or outflow of individuals – and the genes they carry with them – from any given subpopulation. Nevertheless, the results presented here highlight the basic importance of considering proper metapopulation functionality as an additional component of subpopulation viability.

Third, let us consider the statement on “distribution of the deer within the subpopulations” as laid out in the 5-Year Review. While not explicitly defined in the Review or the Recovery Plan, this statement likely refers to the desire to generate and maintain viable CWTD subpopulations (according to the appropriate definition of subpopulation viability as discussed above) across a representative portion of the current range of the subspecies. A review of the current deer abundance across the DPS (as of January 2018) indicates that 70% of the animals (856 of 1224) are in the farthest downstream Group A subpopulation cluster, 14.5% (179 of 1224) are in the Group B cluster, and 15.5% (189 of 1224) are in the Group C cluster. Habitat availability will, of course, limit the total abundance that can be achieved within any given subpopulation, cluster of subpopulations, or across the total metapopulation (DPS). Despite this limitation, it would still be possible to satisfy a condition where at least one representative from each subpopulation Group achieves an abundance consistent with the definition of viability. This represents an extension of the current Criterion 2, going beyond the identification of three viable subpopulations as a necessary condition to achieve recovery.

Bringing this information together, it is possible to construct a revised framework that provides a more explicit definition of population viability, and lays out a possible set of demographic recovery criteria that more comprehensively describe the conditions required for recovery. The following is an example of this framework.

<u>Definition of viability:</u>

- Probability of future population extinction is no greater than 10% over 50 years
- Retention of subpopulation gene diversity (expected heterozygosity) is at least 90% of its current level over 50 years

<u>Definition of secure habitat</u>

- Free from adverse human activities in the foreseeable future and relatively safe from natural phenomena that would destroy its value to the CWTD. Habitat may be secured through means such as purchase, easements, leases, conservation agreements, landowner incentives, memorandums of understanding, and local land use planning or zoning ordinances.

<u>Demographic criterion 1: Population abundance</u>

a) Maintain a minimum of at least [400] CWTD across the Columbia River DPS over a [10]-year period [equal to approximately two CWTD generations];
b) The annual population growth rate (λ) across the DPS averaged over the same [10]-year period is at least [1.02], with positive growth ($\lambda > 1.0$) in each of the last [four] years of the full period; and
c) Maintain a minimum of [three] subpopulations of at least [50] individuals over a [10]-year period, with each of the three subpopulations demonstrating positive growth as defined in criterion 1(b) above.

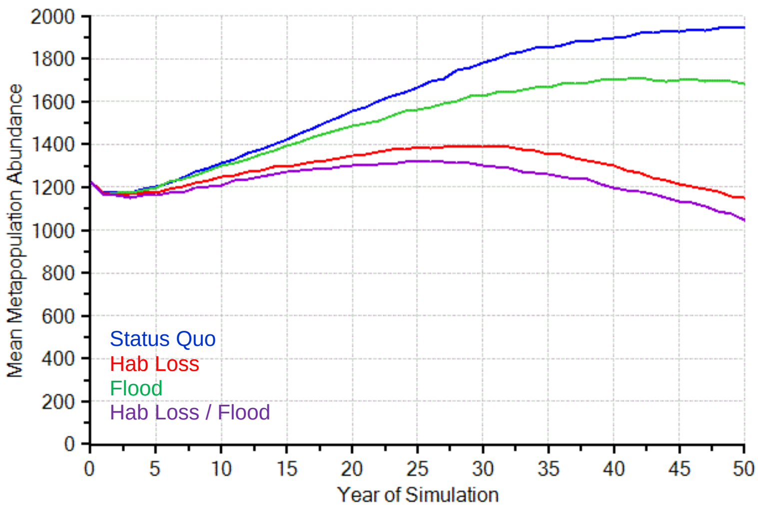
<u>Demographic criterion 2: Distribution</u>

a) Two of the minimum of three subpopulations identified in criterion 1(c) above must be located on secure habitat; and
b) At least one of the minimum of three subpopulations identified in criterion 1(c) must be located in each of the three subpopulation Groups.

This framework borrows its structure from other recent Fish and Wildlife Service recovery plans (e.g., Mexican wolf: USFWS 2017). Remember that the above is only a suggested framework. Specific quantitative metrics are subject to additional discussion, and careful review of the overall framework is necessary to uncover any logical inconsistencies, etc. The important point in this discussion is the addition of key demographic metrics such as population growth rate that significantly strengthen the criteria as a whole. The additional quantitative elements of a definition of viability facilitate a more direct linkage between insights gained from the PVA and decisions around population and/or habitat management activities that are intended to increase viability of individual subpopulations and the larger DPS.

Finally, it is possible to construct one or more threat-based recovery criteria (as discussed in Doak et al. 2015) that, when satisfied, are designed to increase viability of the Columbia River DPS and its component subpopulations. Insights gained from the PVA can be particularly helpful in this regard. Figure 32 shows the mean abundance trajectory of the full DPS metapopulation under each of the four potential future threat scenarios that are presented throughout this PVA report, and assumes a mean overall annual metapopulation growth rate of approximately 0.02 (i.e., the Medium growth condition). It is evident from these predictive models that the Columbia River DPS is not demographically stable when reasonable estimates of future habitat loss across subpopulations – 0.75% or 1.0% of existing habitat each year for 50 years in public or private lands, respectively – are included as a potential future threat. An increase in the risk of higher mortality through severe flooding events also decreases overall DPS growth rates, but to a lesser extent than that predicted in the proposed habitat loss scenarios. Importantly, the figure shows the simulated DPS with the capacity to grow in abundance over the first 25-30 years of the model trajectory, in keeping with the intended mean positive growth rate, but is then followed by a steady decline in abundance as habitat becomes limiting in later years.

Figure 32. Mean 50-year abundance trajectories for the Columbia River DPS (metapopulation) under the range of threat scenarios explored in this PVA, assuming medium population growth rates (r_s = 0.02) and baseline dispersal rates.



Results such as those shown in Figure 32 highlight the need to address the risk of increased threat to CWTD habitats arising from activities like those listed in the threat analysis (Figure 3). This can be achieved through the creation of one or more threat-based recovery criteria that could identify the threshold acceptable rate of habitat loss from threat X that leads to an acceptable proportional reduction of habitat carrying capacity from its current subpopulation-specific or DPS-specific value. An excellent discussion of threat-based recovery criteria and their derivation can be found in Doak at al. (2015).

In conclusion, we can identify the following key messages from this demographic risk analysis:

- The recovery criteria as currently written do not adequately identify the conditions necessary for long-term demographic or genetic viability of the DPS as a whole.
- Under a revised set of recovery criteria that incorporate a more informative set of population demographic characteristics, the Columbia River DPS can be considered for recovery with sustained average population growth over a biologically meaningful time period, and with the risk of future habitat loss across the component subpopulations reduced to a minimum acceptable level.
- Managing demographically and genetically robust subpopulations located in the middle of the DPS distribution – here labeled Group B subpopulations – is critical for maintaining connectivity among the chain of subpopulations that comprise the metapopulation. Ideally, this management activity includes an expansion of suitable available habitat in these critical Group B subpopulations in order to further improve their long-term viability.

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Columbian White-Tailed Deer – Columbia River Distinct Population Segment Assessment of the 2013 Federal 5-Year Review Recommendations

This informal assessment, presented on the following pages in Table 8, was intended to evaluate the status of individual recommendations, and to perhaps determine what may be required to advance implementation of those recommendations that are currently not fully complete. In the more broad sense, many of the actions identified in this Report will help to complete many of the recommendations identified in the 2013 Review. In addition, the assessment identifies where recommendations can be revised for conciseness and clarity.

Of the 44 existing recommendations (including sub-headings under broad recommendation statements) listed in Table 8, ten are considered Done, 26 are considered Ongoing, six are considered Incomplete, one is considered No Longer Relevant, and a final recommendation was recommended for incorporation into a similar statement elsewhere in the list. It is important to remember that this assessment is a simplified examination of the extent of progress made in completing the 2013 recommendations. A large majority of the actions identified during the April 2018 Population and Habitat Viability Assessment workshop were designed to at least in part fill some of the gaps in completing the 5-Year Review recommendations identified in this assessment. A detailed mapping of actions on to Review recommendations has not been conducted here, but can be done by State and Federal management authorities as they develop long-term work priorities for CWTD recovery management.

Table 8. Assessment of the status of Recommendations included in the 2013 Federal 5-Year Review of the recovery program of the Columbia River DPS, Columbian white-tailed deer.

Recommendation	Status	Notes
1. **Conduct a population viability analysis (PVA) of the Columbia River DPS of CWTD to address adequacy of recovery priorities and activities (this recommendation should be conducted as soon as possible as the results will affect other recovery action items for CWTD). Given that such a large proportion of CWTD reside on unprotected habitats, consideration should be given to whether the overall population, minimum secure subpopulations, and distribution of the deer within the subpopulations are still adequate to achieve recovery.**	Done	The PVA that is conducted as part of this project will satisfy this Recommendation.
2. **Identify high quality upland habitat in areas that might support populations of CWTD regardless of land ownership:**		Not about identifying habitat - already completed this exercise and discussion Now it is about how do we get deer there (bottomland and upland). Lack of connectivity, threat of development Identify areas around existing habitat bottlenecks that can be restored to expand/enable movement among/between core habitats Outreach has started but not a concerted effort yet outside of BPA effort. BPA is looking for sites for their mitigation and SBU credits for restoration project on Tennasillahe Island Look at larger sites as well as inholdings connecting river bottomlands populations as well as upland historical habitat range Add to current recommendation: Establish connectivity within Group B area

Recommendation	Status	Notes
2a. Develop a broad-based GIS map to identify potential suitable habitat over a large part of the Lower Columbia River basin, regardless of land ownership.	Done	
2b. Work closely with ODFW, WDFW, CLT, and the Cowlitz Tribe to identify additional high quality upland habitat within the historic range of CWTD.	Ongoing	• May always be ongoing
2c. Conduct outreach to landowners/managers to determine the potential for translocation and restoration activities.	Incomplete	• Coming soon
3. **Explore the feasibility of recovery tools that facilitate the relocation of species into higher quality habitat such as:**		
3a. Section 10(j) of the Act to establish an experimental population of CWTD onto other Federal, State, Tribal, or private lands within CWTD historical range (consider habitat and land use practices that are similar to Douglas County DPS, as well as habitat that is not subject to rising sea levels and the associated stressors of disease and poor-quality forage).	Done	• Explored during the down listing process: Talked about developing a 10(j) population but decided that employing the 4(d) rule would make more sense
3b. Habitat Conservation Planning under section 10(a)(1)(B) of the Act to work with non-federal partners in establishing conservation objectives and planning that would help protect CWTD	Incomplete	

Recommendation	Status	Notes
3c. Discuss a partnership with ODFW and WDFW to facilitate the translocation of CWTD into areas of higher quality upland habitat.	Incomplete	• Currently informal agreement between ODFW and WDFW, but would not end if delisting occurred • Could be formalized as a "cooperative management agreement" if delisted (typically occurs for management reliant species)
3d. Due to past high rates of capture-related mortality, review translocation methods with regard to target habitat types, locations, timing, etc., to evaluate effectiveness. Discuss the pros and cons of various methods currently used and, if warranted, revise/develop methodology to enhance translocation methods, including evaluation of variables such as site specificity, timing, changes in technology and methods (e.g., soft release techniques), etc.	Ongoing	• May always be ongoing; maybe review what existing methodologies are
3e. Work with State, Federal, Tribal, and non-governmental entities to overcome barriers to establishing populations in new areas, being sure to address adequate habitat needs as well as potential damage concerns.	Ongoing	• Yes from a regulatory dimension, but no from a social dimension → still barriers • What activities could help to bring down these barriers?
3f. Develop habitat restoration and management guidelines that will benefit CWTD for private, State, Federal, Tribal, and non-governmental landowners.	Incomplete	
4. **Continue habitat restoration and enhancement efforts on currently occupied CWTD habitat as well as on potential future CWTD translocation areas.**		• Consider whether this recommendation needs a measurable outcome. Is this necessary to achieve recovery?

Recommendation	Status	Notes
4a. Continue habitat restoration and enhancement efforts on the JBH Mainland Unit, including pasture restoration, tree planting for browse and cover, and invasive species control.	Ongoing	
4b. Increase restoration efforts on the Upper Estuary Islands to promote a sustainable subpopulation of animals there.	Incomplete	
5. **Continue predator control on the JBH and Ridgefield NWRs.**	Done	• May always be ongoing
6. **Monitor translocated CWTD.**	Done	• Keep it on the list in case translocation occurs again
7. **Work with ODFW and WDFW to address potential animal damage issues as CWTD expand their range.**	Done	• Mechanism is there to do it now, but managers have not yet tapped into these animal damage tools. The process is different when a species is listed relative to when it is delisted.
8. **Explore options to conduct additional translocations of CWTD (especially females) to Ridgefield NWR.**	Done	• Not just explored, already implemented
9. **Conduct a second controlled trial for FLIR using humans on the ground in pre-arranged locations over the three habitat types normally found during surveys. This will help confirm the previous trial and its finding that FLIR undercounts CWTD by an average of 25 percent.**	Done	• Would you be able to use the information gained to help address some of these other recommendations?
10. **Explore opportunities for the Service or State, Federal, Tribal, and non-governmental partners to acquire lands or conservation easements in areas where CWTD already exist or in areas adjacent to current CWTD subpopulations.**	Ongoing	• Is there sustainable habitat we can acquire?

Recommendation	Status	Notes
11. **Evaluate CWTD body condition on JBH lands:**		• Tried but did not work well – difficult to see fine differences in body fat. • Why is this important – what are the underlying hypotheses? Are these research explorations relevant and useful? (e.g., are data on body fat useful in a place with mild winters?) Is it worth the resources?
11a. Capture, collar, and recapture CWTD repeatedly to assess body fat and pregnancy condition in different habitat types over time and evaluate differences, especially after habitat improvements have been made (e.g., JBH Mainland Unit, Tenasillahe Island, Crims Island, etc.).	Ongoing	
11b. Compare body condition results to Douglas County DPS CWTD conditions.	Ongoing	
11c. Continue documenting diet composition especially as habitat enhancements are implemented.	Ongoing	
11d. Understanding diet composition of CWTD can be useful in understanding forage use and body condition. Given this understanding, habitat manipulations could be implemented and diet information could be re-collected in time increments to understand changes in body condition. This information could provide input to management decisions regarding habitat and forage type, quality, and quantity.	Ongoing	

Recommendation	Status	Notes
12. **Conduct studies at Ridgefield NWR.**		
12a. Continue population estimation methods (e.g., FLIR surveys, ground counts) to monitor population trends for the Columbia River DPS.	Ongoing	• Linked to #9 as methods are verified
12b. Review current population estimation methods, to determine if they are robust enough to adequately assess both true population size and to identify trends in the subpopulations. This includes area that may not have been surveyed before, but which may contain CWTD. The BTD:CWTD ratio may vary from site-to-site, complicating population estimates.	Ongoing	• Part (a) is focused on conducting the population estimation work, while Part (b) is focused on determining if those methods are robust (perhaps reverse these two subsections) – goes back to how we compare current estimation methods
13. **Assess the long-term recovery value of working toward either securing the habitat that maintains the Westport/Wallace Island subpopulation, or obtaining a landowner agreement that provides a management commitment to continue predator control.**		• The majority of these lands have changed hands following family events, so there were some concerns about how management out there might change. The land has changed significantly as management priorities have changed. • Could be included into other recommendations about habitat acquisition (#10) "as other opportunities arise (e.g., Westport)". • Something like this can be discussed in a larger context in how to engage different types of stakeholders, including private landowners.
13a. How important is it to ensure the current management at Westport continues?	Ongoing	

Recommendation	Status	Notes
13b. Should the Service or State, Federal, Tribal, and non-governmental partners invest time and money to do so?	Ongoing	
14. **Review implications of the lack of genetic distinctness between northeastern Oregon white-tailed deer and Columbia River DPS deer.**		
14a. Researchers suggest augmenting the Columbia River DPS gene pool with individuals from the Douglas County DPS and the northeastern Oregon population of *Odocoileus virginianus ochrorous*, the latter of which has proven to be genetically similar to, but more diverse than the CWTD.	Ongoing	• USFWS is not pursuing translocations between the aforementioned populations, or from the Douglas County population, for recovery of the DPS now or in the future.
14b. Researchers suggest that subspecific designation may not be warranted for CWTD due to the observed genetic similarity between CWTD and *O. v. ochrorous*. This potential should be further investigated.	Done	• Per Hopken et al. (2015) there is dubious taxonomic status for *O. v. leucurus* because of <1% sequence divergence among *O. virginianus* sampled from JBH, central OR, NE OR, and SE WA. Further, *O. v. leucurus* did not form a monophyletic clade. • In order to revise taxonomy there would need to be further genetic work to sample the whole *O. virginianus* distribution and do a phylogenetic assessment. Also a new morphometrics study to examine morphology in a way that has not been done would be required. Revising taxonomy would expedite translocations and mitigate inbreeding. • Because of the lack of subspecies level differentiation and low genetic diversity of populations considered to be *O. v. leucurus*, Hopken et al. 2015 recommended the consideration of supplementation of genetic diversity initially between disjunct populations of *O. v. leucurus* (central OR and JBHR). Translocations between the sites would increase genetic diversity in either direction. Finally, consideration of genetic

Recommendation	Status	Notes
		supplementation from *O. virginianus* east of the Cascades into *O. v. leucurus* territory could be considered, but further investigation of taxonomy of the complete range of *O. virginianus* would provide the best scientific information, although not entirely necessary if *O. v. leucurus* genetic diversity continues to decline. Continued genetic monitoring of *O. v. leucurus* is needed to monitor for further declines.
14c. Gather genetic information of CWTD at different sites.	Ongoing	• Sampling was most extensive in a continuation of the Hopken et al. (2015) study. These results are reported in a report submitted to the USFWS on March 18, 2011 (Piaggio and Hopken 2011). However, only samples from Subpopulation Group A (CWTD PVA 2019) have been examined, with one exception of 2 samples from Lord/Walker island, which is part of Subpopulation Group B. Truly, Subpopulation Groups B and C have not been tested for genetic diversity and populations structure. It is important to note that both the published paper and report have documented introgression from *O. h. columbianus* into *O. v. leucurus* in the JBHR.
14d. Cooperate with ODFW and WDFW to gather additional white-tailed deer genetic samples from southeast Washington and northeast Oregon.	Done	• This was accomplished and the results are reported in Hopken et al. (2015)

Recommendation	Status	Notes
14e. Consider the efficacy and feasibility of augmenting the Columbia River DPS with deer from the Douglas County population or the northeastern Oregon population.	Ongoing	• See note for recommendation #14a • The first part of this statement was highly recommended in Hopken et al. (2015), and the second requires more careful consideration. In translocations between *O. v. leucurus* populations, genetic monitoring is recommended given that some samples in JBH have shown introgression with *O. h. columbianus*
15. **Address fawn predation and doe survival.**		
15a. Determine whether predator control needs to continue indefinitely at JBH NWR, Ridgefield NWR, Westport, and other sites.	Ongoing	• Seems unnecessary in light of #5?
15b. Determine if predator control needs to occur prior to translocation efforts, or in conjunction with those efforts.	Ongoing	
16. **Determine why sex ratios in some areas are skewed: natural mortality rate of CWTD on JBH – does 20 percent, bucks 40 percent.**	Combine into #19	• Related to #19
17. **Review the current range of the Columbia River DPS as described in the Revised Recovery Plan and re-evaluate whether additional areas/counties should be included.**	Incomplete	• Why was this recommendation suggested? o Had to define the populations to manage the DPS, animals mainly in this area o Broader issue about historic range and extent to which it is available o Issue with having a listed animal and moving them to new areas o What is the gain of doing this? o If move CWTD out of DPS, then no longer a listed animal

Recommendation	Status	Notes
		▪ Won't count towards recovery ▪ Issue again of connectivity to current population • Relevance of current recommendation: o If thinking only about recovery, then not any more ▪ Recover the DPS o If thinking about population viability in the long-term, then yes • Explored a bit but complicated situation concerning translocating from Roseburg population to Willamette (?). Discuss regulatory issues involved with revising a DPS
18. **Discuss the status of the Upper Estuary Islands subpopulation and its potential to become a 3rd secure subpopulation.**		• Now that deer at Ridgefield, this may no longer be necessary. • Cottonwood Island -- part of connectivity Group B discussion/effort in Recommendation #2 (but keep as line item as Cottonwood is key to connectivity) • Improve the habitat to keep deer on island, as deer don't seem to be staying on island – could also include in Recommendation #4? • Remove Black-tail deer to evaluate improvement for CWTD • Add new recommendation of elk, deer, cattle, etc. competition/management in relation to CWTD
18a. Is it possible to include Wallace Island in the Upper Estuary Islands numbers with the requirement that manual genetic interchange would occur over the long-term if necessary?	No Longer Relevant	

Recommendation	Status	Notes
18b. Evaluate CWTD movement off of Cottonwood Island following the 2010 and 2013 translocations. Attempt to identify why most CWTD leave the island after translocation. Determine whether or not it is worth continuing to try and establish a stable population on Cottonwood Island.	Ongoing	
19. **Recommendations on future management, research, or recovery actions should be developed to address the potential threats that need evaluation given the discussion in this status review:**		2018/2019 population viability analysis (included in this report) provides some guidance on the impacts of selected threats on CWTD subpopulations.
19a. Habitat loss/degradation	Ongoing	
19b. Fawn survival	Ongoing	
19c. Predation pressures	Ongoing	
19d. Climate change / flooding	Ongoing	
19e. Hybridization	Ongoing	
19f. Genetic diversity	Ongoing	
19g. Doe survival	Ongoing	
20. **New (language yet unspecified)**	New	• New methodologies for measuring/monitoring demographic rates (P. Meyers) – important to distinguish this proposed recommendation from Recommendation 12.
21. **New (language yet unspecified)**	New	• Recommend a statement about Safe Harbor Agreements • What it means: A landowner may want to do something on their land that helps deer, but they can return the land back to the baseline condition in the future if desired.

Columbian White-Tailed Deer
Columbia River Distinct Population Segment (DPS)
Prioritized Top-Tier Conservation Actions

The summarized versions of recommended management actions presented below – targeting either CWTD populations themselves or their habitat – are listed in priority order, as determined by a paired ranking procedure conducted by participants of the August 2018 Conservation Planning Follow-Up Workshop held in Ridgefield, WA. The scores listed at the end of the each action statement depict the total number of points accrued for that action across the paired-ranking procedure.

These actions are identified as top-tier actions in the appropriate Working Group reports by their enclosure in light-green boxes. Details associated with each recommended action are presented in the appropriate Working Group report, beginning on page 75 of this document.

Population Action 2.1 Translocate an appropriate number of deer from Tennasillahe to Columbia Stock Ranch (near Deer Island) starting in 2018, and monitor survival and movement of translocated deer with radio-telemetry for the first two years and continue yearly with FLIR, when possible. [Score: 111]

Population Action 3.1 Complete FLIR monitoring of the total DPS within a two year period. [Score: 88]

Population Action 3.4 Continue ground monitoring of doe:fawn to estimate fawn recruitment and road counts and camera surveys to obtain BT:CWTD ratios that are used as a correction factor to FLIR counts. [Score: 82]

Habitat Action 2.1 Re-establish deciduous forested habitats (including expanding riparian vegetation, tree and shrub planting, water manipulation) available with the DPS, and also identify areas outside the DPS where feasible. [Score: 78]

Habitat Action 1.2 Confirm availability of priority parcels of land through engagement with parcel landowners [Score: 71]

Population Action 1.3 Improve fawning habitat by:

- iv. Improving habitat connectivity
- v. Using conservation tools to work with private lands (including SHAs, HCPs, and Partners projects)
- vi. Alter cattle grazing patterns [Score: 71]

Population Action 2.4 Continue to identify additional translocation opportunities. [Score: 71]

Population Action 1.2 Because survival and fecundity are related to body condition, improve forage and browse quality and abundance. [Score: 61]

Population Action 2.2 Enhance recipient site through predator control site prior to translocation, if warranted. [Score: 52]

Population Action 1.1 Continue predator removal/control using action thresholds identified in Refuge management plans at JBH Mainland, Tennasillahe Island, and Ridgefield. [Score: 50]

Habitat Action 1.5 Prioritize sites to restore CWTD to their historic habitat/range and assure their viability, including identifying adjacent upland habitats to the existing DPS. [Score: 44]

Population Action 2.5 Evaluate and improve translocation methodology. [Score: 34]

Population Action 5.3 Genetic sampling during future translocations to evaluate hybridization. [Score: 29]

Population Action 6.1 Collaborate with state DFW and departments of agriculture to ensure that CWTD are included in emerging disease response plans.
Additional Description: WDFW is developing a Chronic Wasting Disease response plan and CWTD will need to be addressed in the plan. Other potential threats are EHD (outbreak in Roseburg CWTD and BTD in 2014) and AHD (could possibly affect CWTD). [Score: 11]

Columbian White-Tailed Deer
Columbia River Distinct Population Segment (DPS)
Prioritized Second-Tier Conservation Actions

The summarized versions of recommended management actions presented below – targeting either CWTD populations themselves or their habitat – are listed in priority order, as determined by a paired ranking procedure conducted by participants of the August 2018 Conservation Planning Follow-Up Workshop held in Ridgefield, WA. The scores listed at the end of the each action statement depict the total number of points accrued for that action across the paired-ranking procedure.

These actions are identified as second-tier actions in the appropriate Working Group reports by their enclosure in light-blue boxes. Details associated with each recommended action are presented in the appropriate Working Group report, beginning on page 75 of this document.

Habitat Action 2.2	Forage Enhancements; e.g.,: Treat invasive plants (e.g., canary grass); Manage grazing (e.g., rotational experiments); Create enhanced forage areas (deer specific?); Fertilizer; Mowing/haying areas; Prescribed burns; Increase presence of pollinators; Implement results identified from “Analysis of habitat to identify insufficiencies” (see Planning) [Score: 30]
Habitat Action 1.4	Model impact(s) of the loss of Tennasillahe population and possible gain of CWTD elsewhere. [Score: 29]
Population Action 3.2	Work with biometrician to establish monitoring intervals to evaluate population trends across the DPS. [Score: 27]
Population Action 1.7	Body condition study **Additional Description**: Deer would be captured in fall and measured for percent body fat using a portable ultrasound. Data would be compared among herds and correlated with fawn recruitment and population change.[Score: 26]
Habitat Action 1.3	Couple connectivity analysis and identified CWTD habitat quality map. [Score: 26]
Habitat Action 1.6	Incorporate information from the PVA in the decision-making process for the Tennasillahe island restoration project. [Score: 25]
Population Action 5.4	Develop a management plan for hybrid animals. [Score: 24]
Population Action 5.2	Resample Ridgefield deer and compare to data collected in 2014-2015 in order to evaluate if hybridization has occurred. [Score: 20]
Habitat Action 4.1	Utilise FEMA to inform flood threat analyses for the species. [Score: 20]
Population Action 3.3	Explore the use of UAVs in FLIR monitoring. [Score: 18]
Population Action 1.6	Collaborate with the DOT and rail lines to investigate methods to quantify and mitigate train and vehicle strikes in high risk areas. [Score: 14]

Habitat Action 1.7 Revise and establish inter-agency communication channels to ensure effective communication of future decisions (including land acquisitions) and where inter-agency input required (e.g. within Inter-Agency bi-monthly calls and face-to-face meetings. Include Columbia Land Trust to bi-monthly calls) [Score: 11]

Population Action 1.5 Add selenium on managed lands in order to increase doe survival. [Score: 7]

Columbian White-Tailed Deer Population Working Group Report

Working Group participants:

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Don Vandebergh, ODFW

Goal 1. In order to maintain a stable or increasing DPS population, increase doe survival and fawn recruitment.

Action 1.1 Continue predator removal/control using action thresholds identified in Refuge management plans at JBH Mainland, Tennasillahe Island, and Ridgefield.

Responsibility:	JBH, Ridgefield
Timeline:	Annually in spring (following FLIR counts and evaluation)
Measurable (Deliverable):	Fawn:doe ratio exceeding action threshold and number of coyotes lethally taken
Collaborators or Partners:	APHIS and Ecological Services
Resources:	~$5000 a month per site
Personnel/Time:	Write annual proposal (~2-3 hours) and review and contract out (~4 days)
Consequences of INACTION:	Fawn survival drops, which causes population decline
Impediments:	Funding availability, potential public concern, can only be completed on public land (i.e., limited to a few subpopulations), better effectiveness if done in consecutive years

Action 1.2 Because survival and fecundity are related to body condition, improve forage and browse quality and abundance.

Responsibility:	JBH, Ridgefield, WDFW, ODFW
Timeline:	Continuous
Measurable (Deliverable):	Acres restored or enhanced, can set targets/thresholds (e.g.,: ≥20% cover of invasives requires treatment)
Collaborators or Partners:	Cowlitz Tribe, Soil Conservation Service, Natural Resource Conservation Service, Conservation Districts, Watershed Council, Volunteers, Friend Group employees, contractors, equipment staff, Partners program, private landowners via SHAs, industry via HCPs
Resources:	$50-70,000 per year per site
Personnel/Time:	As identified above (Responsibility and Collaborators)
Consequences of INACTION:	Unsuitable habitat, which could decrease doe survival and reproduction
Impediments:	Rapid regrowth of invasive species, availability of funds, requirements of other trust resources (e.g., other endangered species requirements), lack of access to some properties/subpopulations

Action 1.3 Improve fawning habitat by:

vii. Improving habitat connectivity

viii. Using conservation tools to work with private lands (including SHAs, HCPs, and Partners projects)

ix. Alter cattle grazing patterns

Responsibility:	JBH, Ridgefield, WDFW, ODFW
Timeline:	Continuous
Measurable (Deliverable):	Increase in fawn:doe ratio
Collaborators or Partners:	Cowlitz Tribe, Soil Conservation Service, Natural Resource Conservation Service, Conservation Districts, Watershed Council, Volunteers, Friend Group employees, contractors, equipment staff
Resources:	$50-70,000 per year per site
Personnel/Time:	As identified above (Responsibility and Collaborators)
Consequences of INACTION:	Unsuitable habitat, which could decrease fawn survival
Impediments:	Availability of funds; Rapid regrowth of invasive species; Requirements of other trust resources (e.g., other endangered species requirements); Difficult to get grazing cooperators or private landowners to alter grazing or land management regimes (relevant to iii), Established grazing management plans for Wildlife Areas that don't necessarily favor CWTD (relevant to iii)

Action 1.4 Develop habitat description for adult and fawning habitat (to accomplish Actions 2 and 3 above).

Action 1.5 Add selenium on managed lands in order to increase doe survival

Responsibility:	USFWS, WDFW, ODFW
Timeline:	Continuous
Measurable (Deliverable):	Selenium levels in fecal samples
Collaborators or Partners:	Volunteers, Friend Group employees, contractors, equipment staff
Resources:	$1K per year for mineral blocks, $20K if selenium levels are tested in fecal samples
Personnel/Time:	1 week a year. As identified above to put out mineral blocks, Testing would require a biologist and technician at selected sites
Consequences of INACTION:	Unknown. Low cost and easily implemented project that may have real benefits.
Impediments:	Deer may have to be trained to use the mineral blocks

Action 1.6	Collaborate with the DOT and rail lines to investigate methods to quantify and mitigate train and vehicle strikes in high risk areas	
	Responsibility:	WDFW, USFWS, ODFW
	Timeline:	Set-up initial meeting within the next 2 years
	Measurable (Deliverable):	Reduction in deer strikes, wildlife underpasses, fencing, etc.
	Collaborators or Partners:	WSDOT, ODOT, BNSS, Union Pacific, Cowlitz Tribe, Volunteers, Friend Group employees, contractors, equipment staff
	Resources:	$5-500k, Cost would depend on type of fix and whether DOT would provide equipment, supplies and personnel
	Personnel/Time:	Agency personnel for 1 week
	Consequences of INACTION:	Vehicle strikes of CTWD as they are dispersing to new areas which could prevent them from occupying suitable habitat
	Impediments:	Funding, support from DOT, Little data on vehicle strikes and areas of high mortality. Some fixes may be expensive. Difficulty establishing success if we have no prior data.

Action 1.7	Body condition study **Additional Description**: Deer would be captured in fall and measured for percent body fat using a portable ultrasound. Data would be compared among herds and correlated with fawn recruitment and population change.	
	Responsibility:	USFWS, WDFW, ODFW
	Timeline:	4 years within next 5-10 years (3-4 sites on LC population, 1-2 sites at Douglas County)
	Measurable (Deliverable):	Report, Comparison of body condition among herds and between Lower Columbia and Douglas County populations.
	Collaborators or Partners:	Cowlitz Tribe, Volunteers, Friend Group employees, contractors, equipment staff
	Resources:	$10K per year per population to fund additional staff and equipment
	Personnel/Time:	One biologist and one tech full time for 2½ months per year
	Consequences of INACTION:	Difficulty assessing: 1) the result of habitat management actions on body condition, 2) if fawn predation is affected by the adult doe's body condition 3) if subpopulations differ in body condition and how does it relate to deer density
	Impediments:	Lack of baseline information on habitat quality. Specific training needed. Ultrasounds are expensive (one already purchased)

Goal 2. Reintroduce CWTD to identified suitable habitat within the DPS to increase connectivity, distribution, and abundance in the DPS.

Action 2.1	Translocate an appropriate number of deer from Tenasillahe to Columbia Stock Ranch (near Deer Island) starting in 2018, and monitor survival and movement of translocated deer with radiotelemetry for the first two years and continue yearly with FLIR, when possible.
Responsibility:	JBH
Timeline:	2018 – 2021
Measurable (Deliverable):	Number of deer moved, number of deer surviving initial translocation, number of deer surviving in subsequent years after translocation, number of offspring produced following translocations
Collaborators or Partners:	BPA, CLT, Ridgefield, Ecological Services (ES), WDFW, ODFW, Cowlitz Tribe
Resources:	Funding for equipment, personnel, supplies – ~$700K to cover 3 years
Personnel/Time:	3 biologists, 2 technicians, and volunteers for the transfer (Dec 1– March 30) with weekly monitoring, Additional time for planning and permitting
Consequences of INACTION:	Status quo (assuming habitat lost to salmon restoration is not restored)
Impediments:	Lack of funding, concerns from agencies and adjacent landowners over animal damage management, social acceptance, logistics of physical transfer

Action 2.2	Enhance recipient site through predator control prior to translocation, if warranted
Responsibility:	JBH
Timeline:	Begins 2018-2019 (for Columbia Stock Ranch transfer)
Measurable (Deliverable):	Number of coyotes removed
Collaborators or Partners:	CLT, BPA, APHIS, ES, ODFW
Resources:	~$5000 per site per month
Personnel/Time:	Additional time to contract APHIS (~4 days)
Consequences of INACTION:	Fawn and doe survival declines, resulting in unsuccessful translocation
Impediments:	Funding availability, potential public concern

Action 2.3 Identify options through additional hunting opportunities to reduce BTD and elk in areas for translocation in order to enhance recipient site prior to translocation, if warranted

Responsibility:	USFWS, WDFW, ODFW
Timeline:	Future translocation sites (2020 and beyond)
Measurable (Deliverable):	Number of BTD/elk removed, population trend
Collaborators or Partners:	Cowlitz Tribe, hunters, private land owners
Resources:	Hunt program would utilize limited agency staff time (several weeks)
Personnel/Time:	Biologist time (several weeks) to setup season structure/issue permits and hunt management
Consequences of INACTION:	Potential of resource competition and interbreeding of BTD and WTD
Impediments:	Timing with state regulations, potential public concern, Agency policies/support, species management plans, timing with state regulations, access to private lands, effectiveness of action w/ large source population surrounding site, success on small land base.

Action 2.4 Continue to identify additional translocation opportunities

Responsibility:	USFWS
Timeline:	Ongoing
Measurable (Deliverable):	Identify 1-2 additional locations
Collaborators or Partners:	WDFW, ODFW, Cowlitz Tribe
Resources:	Personnel, Time
Personnel/Time:	Variable
Consequences of INACTION:	Status quo
Impediments:	Funding availability, potential public concern

Action 2.5 Evaluate and improve translocation methodology

Responsibility:	USFWS
Timeline:	Ongoing
Measurable (Deliverable):	Reduce capture related mortality
Collaborators or Partners:	WDFW, ODFW, Cowlitz Tribe
Resources:	Personnel, Time
Personnel/Time:	Variable
Consequences of INACTION:	Status quo
Impediments:	Time to write up results

Goal 3. Conduct consistent monitoring of the total DPS regularly to establish population trends while exploring alternative methods of population monitoring for total population counts, doe:fawn, and BTD:CWTD ratios.

Action 3.1 Complete FLIR monitoring of the total DPS within a two-year period.

Responsibility:	JBH, Ridgefield, ES
Timeline:	Feb 2019 - Feb 2020
Measurable (Deliverable):	Updated population counts for the entire DPS
Collaborators or Partners:	WDFW, ODFW, Cowlitz Tribe
Resources:	$20,000 - $30,000 per year from ES
Personnel/Time:	Proposal, review, and contracting: 3 weeks
Consequences of INACTION:	Delay in establishing strong population data; limited capacity for good decision-making
Impediments:	Lack of funding, staff time, equipment, weather; Access to public and private lands

Action 3.2 Work with biometrician to establish monitoring intervals to evaluate population trends across the DPS.

Responsibility:	ES, WDFW, ODFW, Refuges
Timeline:	Contact and discuss monitoring intervals with biometrician
Measurable (Deliverable):	Development of a sampling scheme
Collaborators or Partners:	Cowlitz Tribe
Resources:	Personnel or Contractor Biometrician (TBD)
Personnel/Time:	Biometrician time (40 hours) and Biologist time (20 hours)
Consequences of INACTION:	Not establishing appropriate monitoring interval
Impediments:	Availability of biometrician, lack of data to determine the sampling scheme, lack of funding

Action 3.3 Explore the use of UAVs in FLIR monitoring

Responsibility:	JBH, Ridgefield, ES, Regional I&M
Timeline:	2018 – 2021
Measurable (Deliverable):	Working UAV/FLIR system
Collaborators or Partners:	Isa Woo (USGS), OAS, WDFW, ODFW, Cowlitz Tribe
Resources:	$25k for equipment and testing
Personnel/Time:	2 months/year for two people (includes a pilot)
Consequences of INACTION:	Status quo of population monitoring, cost of FLIR may limit monitoring ability
Impediments:	UAVs cannot be used on private lands, uncertain technology, evolving technology, currently do not have an USFW approved drone able to stay aloft >15 min

Action 3.4	Continue ground monitoring of doe:fawn to estimate fawn recruitment and road counts and camera surveys to obtain BT:CWTD ratios that are used as a correction factor to FLIR counts	
	Responsibility:	JBH, Ridgefield, WDFW, ODFW, Cowlitz Tribe
	Timeline:	Ongoing
	Measurable (Deliverable):	Annual data from multiple sites in DPS
	Collaborators or Partners:	ES
	Resources:	Funding for personnel, vehicles and equipment $10k
	Personnel/Time:	50 days of biologist/biotech time. Coordinate with states to implement ground/aerial surveys
	Consequences of INACTION:	Status quo of population monitoring
	Impediments:	Funding availability, staff time

Action 3.5	Explore the use of DNA based population monitoring	
	Responsibility:	USFWS, WDFW, ODFW, Cowlitz Tribe, University
	Timeline:	2-3 years
	Measurable (Deliverable):	Protocol for population monitoring
	Collaborators or Partners:	Volunteers, Friend Group employees, contractors, equipment staff
	Resources:	M.S. student ($80k) or Staff biologist and 2 biotechs ($50k) + lab work ($10k)
	Personnel/Time:	2 years for student or 6 months of time for bio and 2 techs per year of study
	Consequences of INACTION:	Retain current methods of population monitoring
	Impediments:	Funding availability, staff time

<u>Goal 4. Obtain current demographic data to better inform management actions.</u>

Action 4.1 Identify collaborators and acquire funding (~$150-200K) and other resources to conduct demographic studies

Additional Description: These demographic studies would estimate parameters such as sex ratios, adult mortality, overwinter fawn mortality, age structure, movement between subpopulations, natality, and fecundity.

Responsibility:	USFWS (refuges and ES) finds university collaborators. USFWS and the university collaborators reach out to ODFW, WDFW (Hannah Anderson), and Cowlitz Tribe (Erik White) to request assistance with funding.
Timeline:	Identify university collaborator and secure funding by fall 2021. Study completed by the end of 2026.
Measurable (Deliverable):	PhD thesis with possible peer reviewed publications
Collaborators or Partners:	USFWS (refuges and ES), University, ODFW, WDFW, Cowlitz Tribe, other funding sources, and other CWTD experts (Winston, UAF)
Resources:	1-2 USFWS personnel to serve on PhD student’s committee, PhD student (5 years full time), university professor
Personnel/Time:	PhD student ($200k), plus staff time
Consequences of INACTION:	Forced to use old demographic data; status quo of population monitoring
Impediments:	High cost and long timeframe, quality of graduate student, availability of USFWS to serve on student’s committee, lack of funding

Action 4.2 Identify additional sites and demographic parameters beyond those analyzed by Gavin et. al 1984

Additional Description: There is interest in estimating these parameters at sites in groups A, B, and C for comparison between populations at carrying capacity, small/isolated sites, and sites where there is large growth potential. There may be parameters that can be estimated today that were not able to be estimated during the time of Gavin et al. 1984.

Responsibility:	USFWS (Refuges and ES), PhD student, PhD student’s advisor and committee members
Timeline:	Develop during PhD student’s first year (2026-2031)
Measurable (Deliverable):	These sites and parameters will be detailed in PhD student’s study proposal.
Collaborators or Partners:	Additional collaboration by ODFW, WDFW, Cowlitz Tribe, and other CWTD experts as needed.
Resources:	1-2 USFWS personnel to serve on PhD student’s committee, PhD student (5 years full time), university professor
Personnel/Time:	PhD student ($200k), plus staff time
Consequences of INACTION:	Only estimate demographic parameters at one site and those that were estimated in Gavin et al. 1984; still uncertain demographic parameters (e.g., dispersal rate)
Impediments:	Time and resources will be limited

Goal 5. Evaluate the genetic structure and variability of the Douglas County DPS, lower Columbia River DPS, and Northeast Oregon populations in order to answer questions related to taxonomy, hybridization with black-tailed deer, and inbreeding, and guide translocation decisions.

Action 5.1 Use current molecular data and collect additional molecular data as needed to determine the genetic distance between the three populations in order to:

i. Develop and implement a management strategy that maximizes genetic variation among subpopulations through translocations, if warranted
ii. Evaluate if these data suggest that the Douglas County DPS and lower Columbia River DPS populations are taxonomically distinct from the Northeastern Oregon population

Action 5.2 Resample Ridgefield deer and compare to data collected in 2014-2015 in order to evaluate if hybridization has occurred

Action 5.3 Genetic sampling during future translocations to evaluate hybridization

Action 5.4 Develop a management plan for hybrid animals

Responsibility:	USFWS, USDA Wildlife Center, Winston (UAF), ODFW, WDFW
Timeline:	1 year
Measurable (Deliverable):	Report, Publication
Collaborators or Partners:	WDFW, ODFW, IDFG, Cowlitz Tribe, Toni Piaggio
Resources:	$25k for genetic work + Staff time for collection of samples, Samples from eastern OR, eastern WA, and possible ID
Personnel/Time:	1 month biologist time for 4-5 biologist collecting data in different areas
Consequences of INACTION:	Status quo on taxonomy
Impediments:	Availability of samples from eastern WA, OR, and ID

Goal 6. To mitigate potential future risks to population viability, create a response plan for emerging diseases and invasive pathogens.

Action 6.1 Collaborate with state DFW and departments of agriculture to ensure that CWTD are included in emerging disease response plans.

Additional Description: WDFW is developing a Chronic Wasting Disease response plan and CWTD will need to be addressed in the plan. Other potential threats are EHD (outbreak in Roseburg CWTD and BTD in 2014) and AHD (could possibly affect CWTD).

Responsibility:	WDFW, ODFW
Timeline:	As plans are being developed
Measurable (Deliverable):	Completed disease response plans
Collaborators or Partners:	USFWS, Cowlitz Tribe, OR Department of Agriculture, WA Department of Agriculture
Resources:	Small amount of staff time at all collaborating agencies. No monetary resources needed unless there are specific actions related to CWTD.
Personnel/Time:	Staff meeting participation and document review
Consequences of INACTION:	Not prepared for disease outbreaks and/or CWTD not specifically considered (federally threatened species different than game species).
Impediments:	Plans are not developed for all diseases, unknown/novel diseases possible in future. We will need to ensure that response plans are consistent with 4d rule and recovery.

Action 6.2 Determine who to collaborate with regarding invasive pathogens.

Additional Description: Emerald Ash Borer and other invasive pathogens could be on the horizon and have the potential to negatively impact CWTD habitat. In other states like Wisconsin, the Department of Natural Resources is responsible for Emerald Ash Borer response.

Responsibility:	USFWS (Refuge & ES)
Timeline:	2019 start, ongoing as needed.
Measurable (Deliverable):	List of contacts for WA, OR, and federal agencies. List of species pertinent to CWTD and their potential effects.
Collaborators or Partners:	WDFW, ODFW, CLT, Cowlitz Tribe, private landowners, Oregon Dept. of Agriculture, Washington Department of Natural Resources
Resources:	Small amount of staff time at all collaborating agencies.
Personnel/Time:	Document review, meeting/conference call participation
Consequences of INACTION:	Not prepared for disease outbreaks and/or CWTD not specifically considered (federally threatened species different than game species).
Impediments:	Unknown invasive pathogens in the future.

Columbian White-Tailed Deer
Habitat Working Group Report

Working Group participants:
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Sandra Jonker, WDFW (Recorder)
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Chris Lapp, USFWS
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Proposed Revisions of Existing Recommendations from USFWS 5-Year Review

Existing Recommendation #2:

2. Identify high quality upland habitat in areas that might support populations of CWTD regardless of land ownership:
    a. Develop a broad-based GIS map to identify potential suitable habitat over a large part of the Lower Columbia River basin, regardless of land ownership.
    b. Work closely with ODFW, WDFW, CLT, and the Cowlitz Tribe to identify additional high quality upland habitat within the historic range of CWTD.
    c. Conduct outreach to landowners/managers to determine the potential for translocation and restoration activities.

Elements to be included in a revised recommendation:

- Identify suitable CWTD habitat considering criteria:
- Connectivity (covers adjacent)
- Upland habitats
- Likelihood of habitat security persistence and suitability long term (for new habitat)
- These elements are for translocations and acquisition effort

Revised Recommendation 2:

2. Acquire or gain access to habitat for CWTD that prioritizes connectivity and upland habitats for both translocation and acquisition efforts. Use a prioritization scheme involving:
    a. Connectivity
    b. Opportunities for expansion (within and outside DPS as opportunity arises)
    c. Likelihood of habitat security persistence and suitability long term
    d. As opportunities arise pursue lands (e.g., Westport)

<u>Existing Recommendation #4:</u>

4. Continue habitat restoration and enhancement efforts on currently occupied CWTD habitat as well as on potential future CWTD translocation areas.
    a. Continue habitat restoration and enhancement efforts on the JBH Mainland Unit, including pasture restoration, tree planting for browse and cover, and invasive species control.
    b. Increase restoration efforts on the Upper Estuary Islands to promote a sustainable subpopulation of animals there.

Elements to be included in a revised recommendation:

- Management of existing habitat
- Grazing
- Wallace and upper estuary islands as examples
- Develop and implement management plans
- % acreage or area that is managed/enhanced

Revised Recommendation 4:

4. Conduct habitat restoration and enhancement efforts on currently occupied CWTD habitat as well as on potential future CWTD translocation/acquisition areas. Use best available science and adaptive management to inform restoration and enhancement efforts. (Action items on all lands, JBH, upper estuary islands)

<u>Existing Recommendation 19:</u>

19. Recommendations on future management, research, or recovery actions should be developed to address the potential threats that need evaluation given the discussion in this status review:
    a. Habitat loss/degradation
    b. Fawn survival
    c. Predation pressures
    d. Climate change / flooding
    e. Hybridization
    f. Genetic diversity
    g. Doe survival

Elements to be included in a revised recommendation:

- Stay current, relevant on all items
- Add ‘Threats to Habitat’ item to evaluate/quantify affect – use this info to inform securing habitat
- Include future management, research, or recovery actions of these two items a) and d) in recommendation #2 and recommendation #4
- Keep as separate recommendations
- Add disease impact

Revised Recommendation 19:

19. Utilize best available science to monitor current and likely future threats to CWTD to inform the securing and management of their habitat.

PESTLE Analysis

The Habitat group conducted a PESTLE analysis to identify some of the wider systemic opportunities and threats to realizing the recommendations for the conservation of the Columbian white-tailed deer. The PESTLE analysis consisted of reflections on:

Political factors	governmental stability, environmental regulations, tax reforms or political agendas all of which could impact on your work either positively or negatively.
Economic factors	economic growth/decline, financial incentives for particular land-use/water-use practices, minimum wages, local/national/international markets for particular products etc.
Social factors	cultural norms/expectations, population growth rates, age distributions, health consciousness, levels of environmental concern etc.
Technological factors	development of new technologies that can support population monitoring, technological change which might encourage/ discourage natural resource exploitation etc.
Legal factors	change in protected area designation, tax law changes, legislation which prohibits/allows for particular practices etc.
Environmental factors	climate change, ethical purchasing, shifts to more sustainable practices etc.

By analyzing the above factors, organizations and project teams can begin to capture an understanding of the current, historic or future systemic changes which may impact on their work, either positively (presenting an opportunity), or negatively (presenting a threat).

Results of the analysis were as detailed in Table 9 below, with positive and negative impacts linked to specific recommendations linked to habitat work.

Table 9. PESTLE Analysis for Columbian white-tailed deer.

Category	Potential positive impacts	Potential negative impacts	Recommendation links
Political		Political tendencies within the administration regarding delisting opportunities (i.e. whether they see delisting as the priority or species conservation	2
	Oil spill mitigation plans and any other mitigation plans which might present opportunities as well as threats to the deer (e.g. Port authorities, railways, BPA and salmon)	Potential oil spill impacts and other impacts (e.g. channel deepening, salmon spawning ground creation- Tenes. And other sites. **Particular concern over Zone B areas which provide connectivity between Zone A and C**	2, 4, 19
		Department of Interior: are we in line with their priorities too? (could be a positive or negative impact depending on their focus)	2
Economic		Changes in land use	2, 17
		Crop agricultural damage	2, 4
	Hunting of the species as a source of funding		4, 17
	BPA willing to provide funding		2
		Urban development	2, 4, 19
		Lack of capacity to manage new lands as well as existing ones (e.g. habitat restoration)	2, 19
		Funding -Delisting might reduce funding available -State and federal funding limited -Wildlife division -Ecological services recovery budgets -We're stretched now!	2, 4, 17, 19, 20, 21,
		Cost of buying land	2, 17, 19
Social		Multiple landowners	2, 17
		Resistance to more government land ownership	2, 17, 19
		Distrust of government	2, 17
		Lowered acceptance of predator control	4. 20
		Landowner resistance	2, 19

Category	Potential positive impacts	Potential negative impacts	Recommendation links
		Human population growth	2, 17, 19
	Acceptance of hunting opportunity as an incentive to care for the species		4, 17
	Urban wildlife conservation program		2, 9, 17, 20
	Incorporation of public engagement work into refuge Environmental Education programs		2,9, 17, 20
		New kinds of user groups (in particular if the species begins to occupy new lands and spread). Could be an opportunity but definitely need to identify and engage them so they do not compromise the deer	2, 4, 19
		Social devaluation of wildlife	2, 4, 17
		Is there sufficient social tolerance of the species, particularly if it spreads and comes more into contact with people?	2, 4, 17
	Identification and protection of ancestral lands by native groups/ tribes		2, 4
Technological	Use of drones		4, 19, 20
	Genetic tools to help inform population viability		4, 19, 20, 21
	New knowledge of deer nutrition etc.		4, 19, 20, 21
	Deer collars/ GPS		4, 19, 20
	Connecting islands??		2, 4, 19
	Highway crossings		2, 19
		Increased vehicular traffic and potential impact on the species (also development of new/ wider roads etc.)	2, 4, 19
Legal	Hunting regulations (e.g. local ordinance)		2, 4
	Other mitigation requirements for development		2, 4
		Risk of litigation	2, 19

Category	Potential positive impacts	Potential negative impacts	Recommendation links
	Other ESA species restoration work? (Salmon, oak woodland enhancement, cormorant and tern management/ restoration areas?	Changes in USFW recovery regulations (opportunity and/or threat?)	2, 4, 19
		Lengthy process for expanding existing refugia boundaries (act of congress if expanding beyond 10%)	2
		Listed status as a barrier to management	2
Environmental		Predation	
		Agricultural intensification impacts	2, 4, 19
		Recovery v viability??	2, 17, 19
		Risk of oil spills	2, 19
		Climate change -increased soil moisture -flooding risk and extent -Water level rises -Pronounced hydrograph	2, 4, 19
		Existing land management practices	2, 19
	Hunting of other species might reduce competition		2, 4, 20
		New invasives?	2, 4, 19
	Uplands less vulnerable to stochastic events		2
		Disease	19, 21
		Isolation	2, 19

In addition to the above PESTLE analysis the group conducted an initial brainstorm of potential groups/ stakeholders who may be able to support work to conserve the species. This list should be considered as the **beginning** of a process of stakeholder identification which should be continued to identify the full suite of potential stakeholders and in particular the priority groups to engage and how:

- State and federal transport programs
- Hydrograph managers on Colombia river
- USGS
- NOAA- help with modelling future stream flow etc.
- Groups who may possess knowledge on other relevant diseases (CWD)
- USDA for potential invasive plants and other competitors
- Universities:
  - Liverpool England (Note English universities now need to demonstrate impact of their research work)
  - Colorado State University- Human dimension work
  - Washington State University

- NCASI- already linked with work on elk etc.
- Quality deer management (e.g. Texas ranchers and other commercial ranchers who may be able to provide additional advice)
- The scientific literature- Absearch etc.
- Groups who can help us to model damage to dykes etc. when the Big One hits
- Parks and County
- Land Trust
- Vancouver Wildlife League (pro-hunting)
- OHA
- Safari Club
- Cowlitz Game and Anglers
- Teachers (to help with Outreach)
- Diking Districts
- NGOs
  - Wildlife Societies
  - National Wildlife Federation
  - Zoos?
  - Etc.
- Volunteers?
  - To help with management
  - To help with monitoring (needs careful planning to be useful)
- Conservation districts
- Farm Bureau
- Refuge Friends Groups
- DNR
- DLCD Oregon (help protect land from indiscriminate land uses
- Forest Service
- Audubon Society

Short-Term Action Recommendations (2-5 Years)

Challenge 1. There is a need for more high quality, secure habitat for the CWTD allowing for connectivity between existing populations in order to ensure the long-term viability of the population. We have already identified suitable habitat and outreach work has begun to relevant stakeholders. BPA is looking for sites for their mitigation and SBU credits for restoration project on Tennasillahe Island. There is a need to look at larger sites as well as inholdings connecting river bottomland populations in addition to upland historical habitat. (linked to Recommendation 2).

Goal 1. Acquire or gain access to habitat for CWTD that prioritizes connectivity and upland habitats for both translocation and acquisition efforts.

Use a prioritization scheme involving:

a) Connectivity
b) Opportunities for expansion (within and outside DPS as opportunity arises)
c) Likelihood of habitat security persistence and suitability long term
d) As opportunities arise pursue lands (e.g., Westport).

Action 1.1 Identify priority parcels of land in Zone B (Willow Grove, Barlow, Diblee, Wasser)

Responsibility:	BPA (S. Gagnon) to organize group to prioritize and evaluate sites to acquire/protect, which will promote connectivity (genetic exchange) and/or increase abundance in Zone B.
Timeline:	By March 2019
Measurable (Deliverable):	List of priority sites developed
Collaborators or Partners:	Cowlitz Tribe (E. White), USFWS (P. Meyers), ODFW (D. Vanderbergh), WDFW (E. Holman), CLT (D. Roix)
Resources:	2-3 meetings to review GIS, parcel data, 1 field day for site verification
Consequences of INACTION:	Loss of connectivity leading to loss of genetic exchange and isolation of populations in Zones A and C. This could lead to long-term reductions in the viability of these populations.
Impediments:	None

Action 1.2 Confirm availability of priority parcels of land through engagement with parcel landowners

Responsibility:	CLT (Dan R.) and BPA (S. Gagnon) to take the lead in this engagement.
Timeline:	By September 2019
Measurable (Deliverable):	Report detailing status of priority parcels in terms of feasibility of acquisition
Collaborators or Partners:	Jackie F.,
Resources:	Letter, phone calls, etc., to be determined based on list from Action 1
Consequences of INACTION:	Loss of connectivity leading to loss of genetic exchange and isolation of populations in Zones A and C. This could lead to long-term reductions in the viability of these populations.
Impediments:	Time, money to fund effort, lack of interest among private landowners

Action 1.3 Couple connectivity analysis and identified CWTD habitat quality map

Responsibility:	USFWS (P. Meyers) to reach out to WSDOT and complete/circulate map of CWTD habitat connectivity and quality
Timeline:	By January 2019
Measurable (Deliverable):	Map distributed
Collaborators or Partners:	WA-DOT (Kelly M.), OR-DOT
Resources:	GIS and review by CWTD Coordination Team
Consequences of INACTION:	Lack of information to feed into subsequent conservation actions and need information to inform other Actions
Impediments:	Staff time

Action 1.4 Model impact(s) of the loss of Tennasillahe population and possible gain of CWTD elsewhere

Responsibility:	IUCN CPSG (P. Miller)
Timeline:	August 2018
Measurable (Deliverable):	PVA graphs, projected population estimates
Collaborators or Partners:	
Resources:	Vortex
Consequences of INACTION:	Lack of information to feed into subsequent conservation actions
Impediments:	Staff time

Action 1.5	Prioritize sites to restore CWTD to their historic habitat/range and assure their viability, including identifying adjacent upland habitats to the existing DPS.
Responsibility:	ODFW (D. Vanderbergh, H. Biederbeck)
Timeline:	December 2019
Measurable (Deliverable):	Report prioritizing sites taking into account ecological factors and social tolerance.
Collaborators or Partners:	USFW, WDFW, CTI, ODFW, BPA (CWTD Coordination Team)
Resources:	Meetings to review existing analyses and prioritize: DOT, CWTD team, PVA/PHVA, ecological systems data (i.e., SWAP), Human Dimensions data (AWV study), Connectivity data from Landscape Conservation Cooperatives
Consequences of INACTION:	Lack of information to feed into subsequent conservation actions
Impediments:	Willamette Valley and Lewis County have low potential for re-establishment due to high private ownership

Action 1.6	Incorporate information from the PVA in the decision-making process for the Tennasillahe island restoration project.
Responsibility:	CWTD Coordination Team (USFWS, WDFW, ODFW, CTI)
Timeline:	Underway now and on-going
Measurable (Deliverable):	Decisions + rationale communicated in coordination calls and meetings
Collaborators or Partners:	CWTD Coordination Team (USFWS, WDFW, ODFW, CTI), IUCN CPSG
Resources:	PVA analyses and decision-making power of collaborators
Consequences of INACTION:	Lack of information to feed into subsequent conservation actions leading to poor decisions.
Impediments:	Staff time

Action 1.7	Revise and establish inter-agency communication channels to ensure effective communication of future decisions (including land acquisitions) and where inter-agency input required (e.g. within Inter-Agency bi-monthly calls and face-to-face meetings. Include Columbia Land Trust to bi-monthly calls)
Responsibility:	USFWS (J. Siani)
Timeline:	Underway now and on-going
Measurable (Deliverable):	Inter-agency perception of effective communications into decision-making
Collaborators or Partners:	CWTD Coordination Team (USFWS, WDFW, ODFW, CTI), CLT, BPA
Resources:	Monthly meetings
Consequences of INACTION:	Reduced effectiveness and efficiency of inter-agency collaborations
Impediments:	Competing priorities

Challenge 2. Existing CWTD habitat is sub-optimal which thereby limits its ability to support further growth or long-term viability of the population.

Goal 2. Conduct habitat restoration and enhancement efforts on currently occupied CWTD habitat, on potential future CWTD translocation/acquisition areas, and on candidate corridor habitats that could serve as linkages among sites. Use best available science and adaptive management to inform restoration and enhancement efforts.

Action 2.1 Re-establish deciduous forested habitats (including expanding riparian vegetation, tree and shrub planting, water manipulation) available within the DPS, and also identify areas outside of the DPS where feasible

Responsibility:	Refuge staff, Wildlife Area staff, Private Lands Biologists, CLT staff, and private property owners that allow this work
Timeline:	Ongoing
Measurable (Deliverable):	Acres re-established
Collaborators or Partners:	USFW, ODFW, WDFW, CTI, CLT, Clark County?
Resources:	Staff time, equipment, trees, seedlings, funding [find dollar/hectare for restoration to have a reference]
Consequences of INACTION:	Loss of suitable habitat, perpetuation of poor habitat
Impediments:	Funding, staff, space to do work that could be in conflict with existing management strategies, lack of interest of private landowners.

Action 2.2 Forage Enhancements; e.g.,: Treat invasive plants (e.g., canary grass); Manage grazing (e.g., rotational experiments); Create enhanced forage areas (deer specific?); Fertilizer; Mowing/haying areas; Prescribed burns; Increase presence of pollinators; Implement results identified from "Analysis of habitat to identify insufficiencies"

Responsibility:	USFWS Refuge staff, WA & OR Wildlife Area staff, Private Lands Biologists, CLT staff, CIT staff
Timeline:	Ongoing
Measurable (Deliverable):	Acres enhanced
Collaborators or Partners:	USFW, ODFW, WDFW, CTI, CLT, County?
Resources:	Staff time, equipment, seed, fertilizer, herbicides, funding [find dollar/hectare for enhancement to have a reference]
Consequences of INACTION:	Lower deer density, more deer damage to adjacent private lands
Impediments:	Funding, staff, space to do work that could be in conflict with existing management strategies, lack of interest of private landowners.

Action 2.3 Establish corridors

Responsibility:
Timeline:
Measurable (Deliverable):
Collaborators or Partners:
Resources:
Consequences of INACTION:
Impediments:

Challenge 3. The extent to which robust environmental data is made available to or utilised for CWTD is currently insufficient to inform sufficiently the future management of the species, in the face of existing and emerging threats.

Goal 3. Utilize best available science to monitor current and likely future threats to CWTD to inform the securing and management of their habitat.

Action 3.1 Monitor dyke conditions around the CWTD habitat to inform future risk mitigation for the species

Responsibility:
Timeline:
Measurable (Deliverable):
Collaborators or Partners:
Resources:
Consequences of INACTION:
Impediments:

Goal 4. Develop resource information to inform increased knowledge for management of CWTD

Action 4.1 Utilise FEMA to inform flood threat analyses for the species

Responsibility:
Timeline:
Measurable (Deliverable):
Collaborators or Partners:
Resources:
Consequences of INACTION:
Impediments:

Action 4.2 Access and monitor sea level rise data and incorporate as required into planning for the CWTD

Responsibility:
Timeline:
Measurable (Deliverable):
Collaborators or Partners:
Resources:
Consequences of INACTION:
Impediments:

Action 4.3 Engage NCASI in nutritional research relevant to the species

Responsibility:
Timeline:
Measurable (Deliverable):
Collaborators or Partners:
Resources:
Consequences of INACTION:
Impediments:

Long-Term Action Recommendations (5 – 10 Years)

Challenge 1. There is a need for more high quality, secure habitat for the CWTD allowing for connectivity between existing populations in order to ensure the long-term viability of the population. We have already identified suitable habitat and outreach work has begun to relevant stakeholders. BPA is looking for sites for their mitigation and SBU credits for restoration project on Tennasillahe Island. There is a need to look at larger sites as well as inholdings connecting river bottomland populations in addition to upland historical habitat. (linked to Recommendation 2).

Goal 1. Acquire or gain access to habitat for CWTD that prioritizes connectivity and upland habitats for both translocation and acquisition efforts.

Use a prioritization scheme involving:

a) Connectivity
b) Opportunities for expansion (within and outside DPS as opportunity arises)
c) Likelihood of habitat security persistence and suitability long term
d) As opportunities arise pursue lands (e.g., Westport).

Action 1.8 Identify opportunities for translocation downstream of JBH through to Astoria

Responsibility: ODFW (H. Biederbeck)
Timeline:
Measurable (Deliverable): Report disseminated
Collaborators or Partners:
Resources:
Consequences of INACTION: Lack of information to feed into subsequent conservation actions
Impediments:

Action 1.9 Incorporate Clark County into discussion on future of CWTD conservation and suitable land acquisition

Responsibility: Columbia Land Trust
Timeline: Underway now
Measurable (Deliverable): Minutes of meetings showing Clark County inclusion
Collaborators or Partners:
Resources:
Consequences of INACTION: Reduced opportunities for CWTD land acquisition and positive deer management
Impediments:

Action 1.10 Establish landowner/public outreach and engagement program for CWTD with specific focus on agricultural community (understand ESA/4D capacity to help with wildlife damage etc.)

Responsibility: HD?
Timeline: Underway now
Measurable (Deliverable): Pre/post program surveys of key stakeholders
Collaborators or Partners:
Resources:
Consequences of INACTION: Reduced access to suitable land for CWTD and likelihood of landowner positively encouraging CWTD on their land
Impediments:

Action 1.11 Encourage Cowlitz Tribe to include consideration of needs of CWTD in their evaluation of potential land acquisitions

Responsibility: EW CIT?
Timeline: By 2019
Measurable (Deliverable): Inter-agency perception of effective communications into decision-making
Collaborators or Partners:
Resources:
Consequences of INACTION: Reduced effectiveness and efficiency of inter-agency collaborations
Impediments:

Action 1.12 Investigate inclusion of CWTD steering group (or representative) into land planning processes with regards to future development priorities and so inform the group on opportunities for gaining access or threat of loss of access/ compatibility with CWTD conservation strategy (e.g. Counties, Growth Management Act (Commerce Dept), Ports, Annexations, zoning changes, DLCD. Metro. Include the use of our CWTD habitat or potential habitat map. And include in DLCD and County planning maps).

Responsibility:
Timeline: TBD
Measurable (Deliverable): Future land use zoning/planning includes reference to CWTD needs
Collaborators or Partners:
Resources:
Consequences of INACTION: Missed opportunities to influence land use planning with negative impacts on CWTD and risk of investing in population growth within areas designated for development, thereby wasting resources and threatening population viability
Impediments:

Action 1.13 Conduct full stakeholder analysis

Responsibility:	
Timeline:	TBD
Measurable (Deliverable):	Stakeholder analysis report
Collaborators or Partners:	
Resources:	
Consequences of INACTION:	Failure to include priority stakeholders within CWTD conservation planning with negative consequences on deer population viability and growth
Impediments:	

Action 1.14 Update RNWR reintroduction materials with relevant information on CWTD

Responsibility:	
Timeline:	TBD
Measurable (Deliverable):	Updated materials produced
Collaborators or Partners:	
Resources:	
Consequences of INACTION:	Missed opportunity for stakeholder or broader public engagement
Impediments:	

Action 1.15 Identify incentives for landowners to help them feel more comfort with CWTD (e.g. Safe Harbor Agreements, NRCS type incentives)

Responsibility:	
Timeline:	TBD
Measurable (Deliverable):	
Collaborators or Partners:	
Resources:	
Consequences of INACTION:	Hostility towards CWTD and reduced opportunities for population growth/increased population connectivity
Impediments:	

Action 1.16 Expand outreach materials related to potential conflict between CWTD and BTD hunting

Responsibility:	WDFW/ODFW?
Timeline:	TBD
Measurable (Deliverable):	
Collaborators or Partners:	
Resources:	
Consequences of INACTION:	Hostility towards CWTD and reduced opportunities for population growth/increased population connectivity
Impediments:	

Action 1.17 Identify opportunities to associate CWTD habitats with projects for other species (e.g. salmon, larks, terns, cormorants, oaks).

Responsibility:
Timeline: TBD
Measurable (Deliverable):
Collaborators or Partners:
Resources:
Consequences of INACTION: Missed opportunities to capitalise on other projects/resources in support of CWTD conservation
Impediments:

Challenge 2. Existing CWTD habitat is sub-optimal which thereby limits its ability to support further growth or long-term viability of the population.

<u>Goal 2. Conduct habitat restoration and enhancement efforts on currently occupied CWTD habitat as well as on potential future CWTD translocation/acquisition areas. Use best available science and adaptive management to inform restoration and enhancement efforts.</u>

Action 2.4 Establish NRCS co-operative habitat improvement projects

Responsibility:
Timeline:
Measurable (Deliverable):
Collaborators or Partners:
Resources:
Consequences of INACTION:
Impediments:

Action 2.5 Create/ improve existing oak habitat as CWTD-optimal habitat

Responsibility:
Timeline:
Measurable (Deliverable):
Collaborators or Partners:
Resources:
Consequences of INACTION:
Impediments:

Action 2.6 Reduce fencing

Responsibility:
Timeline:
Measurable (Deliverable):
Collaborators or Partners:
Resources:
Consequences of INACTION:
Impediments:

Action 2.7 Create high point within flooding areas

Responsibility:
Timeline:
Measurable (Deliverable):
Collaborators or Partners:
Resources:
Consequences of INACTION:
Impediments:

Action 2.8 Dykes to improve security of lands

Responsibility:
Timeline:
Measurable (Deliverable):
Collaborators or Partners:
Resources:
Consequences of INACTION:
Impediments:

Challenge 3. The extent to which robust environmental data is made available to or utilised for CWTD is currently insufficient to inform sufficiently the future management of the species, in the face of existing and emerging threats.

<u>Goal 3. Utilize best available science to monitor current and likely future threats to CWTD to inform the securing and management of their habitat.</u>

Action 3.2 Utilise USGS analysis to create an 'early warning' system for the species regarding the 'Big One'

Responsibility:
Timeline:
Measurable (Deliverable):
Collaborators or Partners:
Resources:
Consequences of INACTION:
Impediments:

Action 3.3 Collate information on dam/water management within the basin and how it might impact on CWTD management

Responsibility:
Timeline:
Measurable (Deliverable):
Collaborators or Partners:
Resources:
Consequences of INACTION:
Impediments:

Action 3.4 Update WDFW Management Recommendations for CWTD

Responsibility:
Timeline:
Measurable (Deliverable):
Collaborators or Partners:
Resources:
Consequences of INACTION:
Impediments:

Action 3.5 Connect with WSU and OSU for relevant grazing research to inform future planning for the CWTD

Responsibility:
Timeline:
Measurable (Deliverable):
Collaborators or Partners:
Resources:
Consequences of INACTION:
Impediments:

Action 3.6 Undertake further genetic work to determine the extent to which inbreeding continues to pose a threat to the CWTD

Responsibility:
Timeline:
Measurable (Deliverable):
Collaborators or Partners:
Resources:
Consequences of INACTION:
Impediments:

<u>Goal 4. Develop resource information to inform increased knowledge for management of CWTD</u>

Action 4.4 Develop Chronic Wasting Disease Management Plan

Responsibility:
Timeline:
Measurable (Deliverable):
Collaborators or Partners:
Resources:
Consequences of INACTION:
Impediments:

Action 4.5 Connect with relevant Climate Change groups (e.g. UW Climate Change Group and Climate Change Specialist Group) to incorporate expert opinion into future planning for the CWTD in relation to climate change

Responsibility:
Timeline:
Measurable (Deliverable):
Collaborators or Partners:
Resources:
Consequences of INACTION:
Impediments:

Action 4.6 Undertake further taxonomic research into the CWTD

Responsibility:
Timeline:
Measurable (Deliverable):
Collaborators or Partners:
Resources:
Consequences of INACTION:
Impediments:

Action 4.7 Engage Quality Deer Management group in future planning for the CWTD

Responsibility:
Timeline:
Measurable (Deliverable):
Collaborators or Partners:
Resources:
Consequences of INACTION:
Impediments:

Action 4.8 Incorporate white-tailed deer hunting knowledge across the USA into future conservation planning for the CWTD (including work on the Florida Key white-tailed deer)

Responsibility:
Timeline:
Measurable (Deliverable):
Collaborators or Partners:
Resources:
Consequences of INACTION:
Impediments:

Action 4.9 Engage agricultural research stations (e.g. US Department of Agriculture) in future planning for the CWTD

Responsibility:
Timeline:
Measurable (Deliverable):
Collaborators or Partners:
Resources:
Consequences of INACTION:
Impediments:

Action 4.10 Once priority conservation management actions taken, remodel PVA for the CWTD to monitor impacts and evaluate success

Responsibility:
Timeline:
Measurable (Deliverable):
Collaborators or Partners:
Resources:
Consequences of INACTION:
Impediments:

Planning Actions identified but not specified by the Working Group

Short-Term Actions

Action A Analysis of habitat to identify insufficiencies

Long-Term Actions

Action B Experiment with habitat types, structure, etc. to better understand suitable habitat

Action C Develop a strategy to create corridors

Action D Develop Best Management practices for suitable CWTD habitat

Action E Develop habitat design criteria

Action F What does good fawning habitat look like? – brushy forest, shrubs – increasing this type, would decrease the need for predator control, etc.

Action G Configuration of landscape for successful fawning, hiding cover, foraging areas, watering areas, etc, habitat?

Action H NRCS cooperative habitat management projects

Supporting Information for Development of Selected Action Items

The information presented below is a summary of the Working Group discussions that preceded the final specification of actions related to habitat management, in relation to the 5-Year Review recommendations that the group revised as described earlier in this report.

<u>Recommendation 2 Action Items</u>

Brainstorm discussion

1. Get parcels in Zone B (Willow Grove, Barlow, Diblee, Wasser, etc.)
    a. Steve G. to organize a group to prioritize sites to acquire/protect, identify sites that will promote connectivity (genetic exchange) and/or increase abundance in Zone B. A List of sites will be developed. By 2019. Consequences of inaction would be loss of connectivity (genetic exchange lost). Isolation of A and C
    b. CLT reaches out to identified parcel owners to evaluate availability of property for CWTD. A contact will be made. By 2020 Consequences of inaction would be loss of connectivity (genetic exchange lost). Isolation of A and C

2. Couple connectivity analysis and identified CWTD habitat quality map (more in depth analysis); link to PVA – possible to model impact of the loss of Tenasillahe CWTD population (and additional CWTD elsewhere?)
    a. Paul M. reach out to WSDOT, complete (if necessary) and circulate map of CWTD habitat connectivity and quality. By 2019. Map distributed. Inaction = lack of information to feed actions stated below.
3. Identify adjacent upland habitats to DPS
    a. Organize group to prioritize sites to restore CWTD to their historic habitat and assure their viability. A List of sites will be developed. As opportunity presents itself.
4. Look at opportunities for translocations downstream of JBH all the way to Astoria.
    a. Herman B,
5. Decisions on land acquisition for BPA (has $15million) (Steve G. underway now)
    a. Two big landowners
        i. ~1,000acres and 3,000acres – Zone C
        ii. BPA appraisals in hand;
            1. Need to review appraisals;
        iii. Need the replacement and management decisions to know what is enough to secure habitat; what are the options?
        iv. Meet with USFW and States, Tribe
        v. Move CWTD to Columbia Stock Ranch, East Fork, Scapoose?;
        vi. Do a trial translocation from Tennasillahe;
        vii. Use PVA to inform these decisions;
        viii. Inter-Agency bi-monthly calls
            1. use May Inter-Agency to debrief and next steps;
            2. provide action item alerts to team meeting to be able to provide timely input;
            3. include incorporating acquisition status/news/ into bi-monthly calls;
            4. include Columbia Land Trust to bi-monthly calls
            5. Revisit/bring Clark County into discussion. Initially Land Trust as liaison (current). . . .More formal as translocations progress.

6. Landowner/ public outreach/engagement in support for CWTD
   Scoping…HD work on both pre and post
   WDFW private lands biologist
   Develop messaging social marketing

   Outreach to agricultural community specifically

   Understanding of ESA / 4D capacity to help with damage …meetings with farm groups (focus groups and town hall meetings) including follow up.
7. Fazio, Anderson dairy, etc., may become available for purchase
   a. Evaluate for CWTD habitat; opportunities after salmon restoration; maintain contact with landowners
8. BPA – keen to know which sites agencies want – discuss (bigger than deer)
9. Chehalis Tribe. Initially Cowlitz Tribe speaks to Chehalis Tribe.
10. Cowlitz Tribe includes emphasis of CWTD in their evaluation of potential acquisitions.
    a. EW CIT by 2019
11. Insert/be involved into land planning processes with regard to development and inform opportunities for gaining access or loss of future compatibility: Counties, Growth Management Act (Commerce Dept.), Ports, Annexations, zoning changes, DLCD. Metro. Include the use of our CWTD habitat or potential habitat map. And include in DLCD and County planning maps.
12. Analysis of stakeholders and identify them.
13. Development of outreach / informational materials for agencies. Update RNWR reintroduction materials.
14. Identify incentives for landowners to help them feel more comfort with CWTD

    Safe harbor agreements

    NRCS type incentives
15. Outreach surrounding potential conflicts with hunting of black-tails -WDFW / ODFW….expand existing outreach as needed.
16. Look for opportunities to associate CWTD habitats with projects for other species i.e. salmon, larks, terns, cormorants, oaks.

<u>Recommendation 4 Action Items</u>

Brainstorm discussion

Cover

1. Expand riparian vegetation
2. Tree planting
3. NRCS cooperative habitat improvement projects
4. Create/improve oak habitat

Land management

5. Reduce fencing
6. Creating high points within flooding areas
7. Dykes to improve security of lands
8. Managing disturbance
9. Create corridors

Forage Enhancements

10. Treat invasive plants (e.g., canary grass)
11. Manage grazing (e.g., rotational experiments)
12. Create enhanced forage areas (deer specific?)
13. Fertilizer

14. Mowing/haying areas
15. Prescribed burns
16. Increase presence of pollinators
17. Implement results identified from Analysis of habitat to identify insufficiencies (see Planning)

Planning

18. Analysis of habitat to identify insufficiencies
19. Experiment with habitat types, structure, etc. to better understand suitable habitat
20. Utilize WSDOT connectivity to identify bottlenecks/deficiencies between subpopulations
21. Develop strategy to create corridors
22. Develop Best Management practices for suitable CWTD habitat
    a. Use Evidenced Based Conservation Journal
        i. Conservationevidence.com
        ii. Use Mule deer conservation strategies as a template for each landscape
    b. Develop habitat design criteria
23. What does good fawning habitat look like? – brushy forest, shrubs – increasing this type, would decrease the need for predator control, etc.
24. Configuration of landscape for successful fawning, hiding cover, foraging areas, watering areas, etc., habitat?
25. NRCS cooperative habitat improvement projects

<u>Recommendation 19 Action Items</u>

Brainstorm discussion

Threats

1. Utilize NOAA for flood threat analysis
2. Utilize USGS analysis for the "big one"
3. Monitor dyke conditions around habitat
4. Access and monitor sea level rise data
5. Develop Chronic Wasting Disease Management Plan; EHD
6. Dam/water management in basin and how it affects basin
7. UW Climate Change group
8. Climate Change Specialists Group

Pro-active actions

9. Update WDFW Management Recommendations for CWTD
10. WSU and OSU for grazing research
11. NCASI research on ungulate nutrition
12. Further genetics work to determine threats of inbreeding
13. Taxonomy research
14. Quality Deer Management group
15. White-tail deer hunting knowledge across U.S.A.
16. Florida Key white-tail deer
17. Agricultural research stations (U.S. Dept. of Agriculture)
18. Use data/actions taken and remodel PVA

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Appendix I

Columbian White-Tailed Deer
Population and Habitat Viability Assessment Workshop
24-26 April 2018

Workshop Participants

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Appendix II

Recovery Planning for Columbian White-Tailed Deer
Workshop I: Population Viability Analysis

13 – 15 December, 2017
Hampton Inn and Suites Portland/Vancouver
Vancouver, WA

WORKSHOP AGENDA

DAY ONE: Wednesday, 13 December

9:00 Welcome and workshop opening
(*Sandra Jonker, WDFW)*

9:10 Participant introductions (name, affiliation, involvement with CWTD conservation)

9:30 Background presentations

1. Recovery Planning Background (20m)
(*Sandra Jonker, WDFW)*
2. Federal Downlisting and 4d Rule (20m)
(*Jennifer Siani, USFWS*)
3. Population Status Overview (20m)
(*Paul Meyer, USFWS*)

10:30 Coffee / tea break

10:45 The role of population viability analysis and species conservation planning in the CWTD recovery planning process (*Phil Miller, CPSG*)

11:30 Review of existing questions to guide PVA model structure and function

12:00 Lunch

1:00 Threats analysis for CWTD metapopulation

3:15 Coffee / tea break

3:30 Threats analysis for CWTD metapopulation (cont'd)

4:15 A technical introduction to population viability analysis modeling and the *Vortex* PVA software tool (*Phil Miller, CPSG*)

4:45 Wrap-up for the day; introduction to Day 2 activities

5:00 Adjourn

Evening Dinner on your own

Appendix II (Contd.)

Recovery Planning for Columbian White-Tailed Deer
Workshop I: Population Viability Analysis

13 – 15 December, 2017
Hampton Inn and Suites Portland/Vancouver
Vancouver, WA

WORKSHOP AGENDA

DAY TWO: Thursday, 14 December

8:30	Review of Day 1; questions after overnight contemplation
8:45	Discussions on model structure, function, and input data
10:00	Coffee / tea break
10:15	Discussions on model structure, function, and input data (continued)
12:00	Lunch
1:00	Discussions on model structure, function, and input data (continued); evaluation of “status quo” scenario dataset
3:15	Coffee / tea break
3:30	Potential for interactive evaluation of preliminary status quo model structure and performance
4:30	Wrap-up for the day; introduction to Day 3 activities
4:45	Adjourn
Evening	Dinner on your own

DAY THREE: Friday, 15 December

8:30	Review of Day 2; questions after overnight contemplation
8:45	Tie up loose ends on “status quo” scenario dataset
9:15	Discussion of management alternatives to evaluate using model
10:00	Coffee / tea break
10:15	Discussion of management alternatives to evaluate using model (continued)
11:15	Plenary discussion of next steps: Overall workflow, timeline, virtual meeting options, etc.
12:30	Adjourn – Close of workshop
	Lunch

Appendix III

Recovery Planning for Columbian White-Tailed Deer
Workshop II: Population and Habitat Viability Assessment

24 – 26 April, 2018
WA Department of Fish and Wildlife Regional Office
Ridgefield, WA

WORKSHOP AGENDA

Day 1: Tuesday, 24 April: The Biological System

Morning (9:00AM – 12:00PM)

Welcome
Introductions
Background Presentations
- Species Recovery overview *(Sandra Jonker, WDFW; Paul Meyers, USFWS*) (45 minutes)
  - Current conservation status; Population status overview, future management concerns/issues
  - Q&A, discussion
- Overview of PVA (*P. Miller, CPSG*) (90 minutes)
  - Review of model structure, input, and output
  - Implications for management
  - Q&A, discussion

Lunch

Afternoon (1:00PM – 5:00PM)

Plenary review of recommendations listed in Federal 5-Year Review
- Status of recommendation implementation: completed, not completed, no longer relevant
- Relative importance of each recommendation into the future – *Would what we have achieved for each recommendation still be considered sufficient within a changing environment?*
- From what to why- *where recommendations haven't been implemented (and yet they are still relevant) what could we learn to inform future targets and how to achieve them?*

Theming of recommendations

Initiate working group activities
- Working Group Task 1
  - Review existing recommendations for clarity; add new recommendations as appropriate based on new information obtained since 2013, and on results from PVA

Appendix III (Contd.)

Recovery Planning for Columbian White-Tailed Deer
Workshop II: Population and Habitat Viability Assessment

24 – 26 April, 2018
WA Department of Fish and Wildlife Regional Office
Ridgefield, WA

WORKSHOP AGENDA

Day 2: Wednesday, 25 April: The Anthropological System

Morning (8:00AM – 12:00PM)
- Plenary session: Report back on evaluation of existing and new action recommendations
- Working group Task 2
  - PESTLE analysis – identifying constraints/obstacles to implementing action recommendations

Lunch

Afternoon (1:00PM – 5:00PM)
- Continue with working group Task 2 – PESTLE analysis (if required)
- Plenary session: Report back on results and insights from PESTLE analysis
- Working group Task 3
  - Action planning – specifying actions that will achieve implementation of recommendations

Day 3: Thursday, 26 April: Planning for Conservation Action

Morning (8:00AM – 12:00PM)
Continue with working group Task 3 – action planning

Lunch

Afternoon (1:00PM – 5:00PM)
- Continue with working group Task 3 – action planning
- Plenary session: Report back on identified actions
- Synthesis of actions across groups – overlap, common themes, antagonisms, etc.
- Moving forward – next steps
- Wrap-up
- Closing

Appendix IV

Recovery Planning for Columbian White-Tailed Deer
Workshop II: Population and Habitat Viability Assessment
Follow-Up Workshop

1 August, 2018
WA Department of Fish and Wildlife Regional Office
Ridgefield, WA

WORKSHOP AGENDA

9:00am – Welcome and Overview

9:15am – Break-out into Population and Habitat groups to review/finalize items for group presentation.

10:15am – Break

10:30am – All group review and prioritization of Population and Habitat Actions

12:30pm – Lunch – **Please bring your own lunch!**

1:00pm – Discussion of additional PVA runs with Phil Miller (on phone)

2:15pm – Break

2:30pm – Continued all group review and prioritization of Population and Habitat Actions

4:00pm – Next steps

5:00pm – Wrap up