

City of Rockaway Beach

Sourcewater Protection Plan Development

Advisory Committee (SPPDAC) Meeting Agenda



Date: Monday, July 29, 2024
Time: 10:00 AM – 12: 00 PM
Location: Rockaway Beach City Hall, 276 Hwy 101 – 2nd Floor Conference Room

Join here to attend the meeting remotely:

<https://us06web.zoom.us/j/84314892855?pwd=uwbM0TSIHBBAUbqzMoPsbojVdiggrb.1>

Meeting ID: 843 1489 2855

Passcode: 323104

Dial by your location

253 215 8782 US (Tacoma)

How to Provide Public Comment:

- Written Comments – submit in person at meeting or online at <https://corb.us/advisory-committees/>
 - In Person – sign-up sheet and instructions will be located on the table inside the meeting room.
 - Virtually on Zoom – use the “raise hand” feature when the Chair announces it is time to do so.
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1. **CALL TO ORDER** – Sandra Johnson, Chair

2. **ROLL CALL**

3. **APPROVAL OF MINUTES** – None scheduled

4. **PUBLIC COMMENT**

5. **NEW BUSINESS** – None scheduled

6. **OLD BUSINESS**

a. **Prioritizing Risks**

Suzanne de Szoeki, GSI Water Solutions, Inc., will continue presenting the surface water and groundwater risk prioritization tables that include suggested scores from the Sourcewater Protection Plan (SPP) Team and from the SPPDAC's July 9 meeting. Committee members to review and provide comments on the tables.

i. **Draft Rockaway Beach Source Water Protection Plan Risks Prioritization Table (Surface Water)**

This table shows input gathered from the SPP Team and the SPPDAC thus far on risk likelihood and impact scores and the initial risk prioritization recommendations by the SPP Team meeting and the SPPDAC (shown in bold and underlined). SPPDAC changes

to SPP Team recommendations are identified in text and shown in blue. On July 9, the SPPDAC reviewed risks from the beginning of the table through Riparian Impacts.

ii. Rockaway Beach Source Water Protection Plan Risks to Groundwater Table

This table shows input gathered from individual SPP Team members thus far on risk likelihood and impact scores. Jetty Creek is the primary focus of the Drinking Water Protection Plan, but we are also documenting groundwater risks for context regarding the City's water management issues.

b. Next Steps

c. Committee Comments

7. ADJOURNMENT

NOTICE OF POSSIBLE QUORUM:

A quorum of the **CITY COUNCIL** may attend this meeting.

No deliberations or decisions will be conducted by the City Council at this meeting.

DRAFT

Rockaway Beach Source Water Protection Plan Risks Prioritization Table (Surface Water)

7/22/2024

Identifying and prioritizing potential risks will form the foundation for developing strategies to protect drinking water quality. Risks can be prioritized based on the likelihood of their occurrence and the severity of their impacts to drinking water sources, water quality, and infrastructure. Using a scale of 1-5, please indicate how you would rate these two aspects for each risk below.

Likelihood		Impact	
1	Rare/very unlikely	1	Insignificant
2	Unlikely	2	Minor
3	Possible	3	Moderate
4	Likely	4	Severe
5	Almost certain	5	Catastrophic

Risks to Jetty Creek Drinking Water Source

Notes from July 9 Advisory Committee meeting:

- The Advisory Committee discussed whether the Plan should focus on risks within Jetty Creek source watershed only (up to the POD or Water Treatment Plant) or include risks to infrastructure and distribution system downstream of the watershed. The Advisory Committee suggested including risks and strategies in the watershed up to the water treatment plant and capturing other risks downstream of the WTP in an addendum or appendix to the Plan.
- The Advisory Committee reviewed and discussed the risk likelihood and impact scores done by the Team and recommended revisions to some of the scores (shown in blue and called out in several spots in the table).
- The Advisory Committee discussed the interpretation and working definitions of “risk likelihood” and “risk impact” to use when scoring risks.
 - Generally, the approach to scoring risks is to define “risk likelihood” as the likelihood of the identified risk impacting the water source and causing the impacts described in the third column of the table. “Risk impact” is defined as the severity of the impact of those risks if they were to impact the water source.
 - For example, highly erodible soils are likely to increase turbidity and contribute sediment to the water source, so the Team ranked that risk likelihood as a 4 (Likely), and the impacts of that risk were ranked as a 4 (Severe) since it severely impacts the water source.
- 20-year planning period used for prioritizing risks

Risk Category	Risk	Description and Impacts	Comments/Questions	Risk Likelihood (scale of 1-5)	Risk Impact (scale of 1-5)
Natural Hazards	Highly Erodible Soils	80% of the stream miles (18.58 mi) within 500 feet of the stream in the source water area contain soils with high erosion potential (USWA, 2016). Highly erodible soils contribute sediment and potential contaminants at a higher rate to the water source, increasing turbidity and decreasing water quality. There are steep slopes in the watershed, and significant rain events are expected in the wet season.	<p>Look into sources of data. DEQ can look into providing more data.</p> <p>Most of the risk assessments are based on ~8-year old data. Would the city be able to support a reassessment of current conditions? For example about landslides and soils data from before recent logging. Could potentially get updated maps from DEQ if possible and if Team & Committee find it necessary.</p> <p>High risk. Steep slopes in the watershed, significant rain events expected in wet season (and a history of erosion and sedimentation post harvest)</p> <p>Likely to get continued input of sediments. Should plan for that while working to implement solutions to reduce input.</p> <p>1.5 to 2 inches of rain in 24 hours will move sediment and turn color regardless of cover type and activities. What BMPs does the water district have to address this risk? Forest soil organic matter can significantly reduce erosion. Cable based harvest systems and larger buffers minimize soil disturbance and leave intact organic matter. Forested buffers also can create sediment when trees blow over and uproot near streams. There is a lot of good data on sediment and harvest operations from studies done by the watershed co-op, Hinckle Creek, Alsea, and Trask Watersheds. The biggest factors in increased sedimentation will be geology and rainfall. Harvests under the FPA rules can increase sedimentation but it will be for a short duration and be within the natural variation of the system.</p> <p>The City has a settling pond off-channel – the issue is that sediment builds up in front of fish screen. This impacts operations. Active management is required annually.</p>	<p>3 4 2-3 4 4 4</p> <p style="text-align: center;">4</p>	<p>2 3 1-2 3 4 2-3</p> <p style="text-align: center;">4</p>

Risk Category	Risk	Description and Impacts	Comments/Questions	Risk Likelihood (scale of 1-5)	Risk Impact (scale of 1-5)
Natural Hazards	Landslides	Landslide deposits (non-rock material) are mapped near the intake and in the mid-watershed (USWA, 2016). Landslides can increase turbidity in the water. A 2015 landslide closed a road, and several small landslides have been observed. There are many steep slopes in the watershed.	<p>Look into sources of data. ODF publishes high landslide hazard location data; we could look into this more. DEQ can look into providing more updated data, but could take a few months.</p> <p>What level of detail do we want our analysis to be for this risk? We can consider evaluating certain parts of the watershed more closely.</p> <p>Are there risks, such as liabilities, associated with landslides and cleanup?</p> <p>This is a high risk, lots of steep slopes in watershed. Currently majority of the watershed was recently harvested, leading to higher current landslide susceptibility.</p> <p>Risk impact could be dependent on location.</p> <p>At a natural intensity and frequency, they can benefit stream systems by adding woody debris. Recent additions to the FPA rules require leaving trees in certain areas of steep slopes so when they slide sometime in the future, wood is added to the stream. In the last 11 years even with the harvest there hasn't been a major landslide in the watershed. Large forested buffers around streams can act as a barrier or at least slow down velocity of slides, reducing the amount of material that reaches the stream. Slides are acute events. Sedimentation from Minor to moderate severity slides can be mitigated by shutting down the intake when high rains are expected.</p> <p>Seems to be a higher risk of shallow landslides but not deep landslides that would be more likely to affect the water supply.</p> <p>Other water systems in the area have had their infrastructure impacted by landslides.</p> <p>Maps of water intake would be helpful, and input from City on infrastructure risk.</p> <p>Several 2015 landslides had large impacts to water system.</p>	<p>3</p> <p>3</p> <p>1</p> <p>4</p> <p>4</p> <p>2</p> <p><u>3</u></p>	<p>2</p> <p>4</p> <p>2-4</p> <p>3</p> <p>4</p> <p>3</p> <p><u>3</u></p>

Risk Category	Risk	Description and Impacts	Comments/Questions	Risk Likelihood (scale of 1-5)	Risk Impact (scale of 1-5)
Natural Hazards	Drought and Low Streamflows	<p>Drought and low streamflows put the City at risk of water supply shortages and decreased drinking water quality. Low streamflows can increase water temperatures, which may introduce toxic algal blooms. Low flows have a higher concentration of contaminants.</p> <p>Climate change is projected to cause more frequent and severe droughts and low streamflows, which increases the impacts of other risks, such as high stream temperatures, sediment, pollution, dissolved oxygen, algae, and bacteria counts.</p>	<p>High risk of drought, younger age stands will reduce water in Jetty Creek during dry seasons. Drought conditions will increase due to climate change as extreme fluctuations continue.</p> <p>Has the city seen a decline in water availability since the harvests? What is the current water draw from Jetty Cr?</p> <p>Lots of uncertainty in the impact. Some aspects dependent on other conditions (sufficient shading may keep temps down)</p> <p>The single most important factor impacting low stream flows is rainfall, and then geology. Low stream flows are exacerbated by the fact that the city uses the most water when it's at its lowest point. As the city grows and tourism increases this will become more of an issue and can only be solved by adding additional water sources or greater storage.</p> <p>There are several studies highlighting the impacts of forest type on stream flows. The topic is complex and depending on geology has mixed results. In general trees and other plants use water by intercepting rain and it evaporating from foliage before it hits the ground, and by transpiration. Typically when forests are harvested there is an increase in available surface water. As trees mature and begin to use more water there can be a decrease in surface water, and eventually a return to the base line. The impacts have been studied in small drainages using management practices that haven't been used in 60 years. For larger drainages individual harvests have less of an impact. About 20% of a drainage needs to be harvested to impact surface water flow. Larger riparian buffers may also reduce any increase in surface water due to recent harvest. Since Jetty Creek has been managed forest for greater than 60 years, maybe longer, the base line for the water system has been managed forest. A harvest would typically increase available surface water for 2-10 years and then return to baseline.</p> <p>City may have historical streamflow data for Jetty Creek, streamflows may have been lower in recent years.</p>	<p>3 5 2-3 4 4 5</p> <p style="text-align: center;"><u>5</u></p>	<p>4 4 3-4 3 4 4</p> <p style="text-align: center;"><u>5</u></p>
Natural Hazards	Climate Change	<p>Climate change exacerbates existing risks to the drinking water source. It is projected to cause more frequent and severe droughts and low streamflows, which increases the impacts of other risks such as high stream temperatures, sediment, pollution, dissolved oxygen, algae, and bacteria counts. Longer, drier summer months reduces streamflows, thereby reducing water supply when demand is highest. Increasing temperatures and droughts also increase the risk of wildfires in the watershed.</p> <p>Climate change is projected to increase winter precipitation in the form of rainfall and decrease snowpack, which can increase erosion and sediment transport to streams. Storms are also likely to increase in severity and frequency, increasing the risk of flooding and sediment transport to streams.</p>	<p>Team decided to incorporate climate into individual hazards, and make it a separate risk to stand out and reiterate the potential impacts.</p> <p>Lots based on predictions. Some uncertainty in what could happen. Impact could be more or less depending on what actually happens.</p> <p>Climate is always changing and is a relatively slow process that we can adapt to.</p> <p>Harmful algal blooms concern?</p> <p>Oregon coast is designated as "disadvantaged" mainly because of climate change (by OHA & federal orgs).</p>	<p>3 5 1 3 4 5</p> <p style="text-align: center;"><u>5</u></p>	<p>3 4 2 3 4</p> <p style="text-align: center;"><i>Depends on the event specifically</i></p> <p style="text-align: center;"><u>5</u></p>

Rockaway Beach Source Water Protection Plan Risks Prioritization Table (Surface Water)

Risk Category	Risk	Description and Impacts	Comments/Questions	Risk Likelihood (scale of 1-5)	Risk Impact (scale of 1-5)
Natural Hazards	Earthquake	The entire Oregon Coast is at risk of a severe Cascadia Subduction Zone earthquake. The effects of an earthquake could include destruction of water system infrastructure, landslides, and potential contamination of drinking water. Tsunamis following an earthquake would intensify these effects and have additional effects.	Uncertainty as to when the “big one” will hit, but likely to come someday. Depends on the location of the earthquake and severity. (Impact level 4 for worst scenario).	3 4 1 4 5 2 3	5 5 5 4 5 4 5
Natural Hazards	Tsunami	Rockaway Beach is at a higher risk of a tsunami than Tillamook County as a whole (NHMP, 2023). The water treatment plant and public works building are exposed to tsunami (CSZ M9.0-med) and have a greater than 50% probability of moderate to complete damage from a CSZ earthquake (NHMP, 2023). A tsunami could destroy vital infrastructure and result in water supply shortages, potential saltwater intrusion, and other contamination of drinking water.	High risk to infrastructure, assuming Treatment plan is within tsunami zone. Dependent on the earthquake happening first, but anything within the tsunami zone at risk. Dependent on location of earthquake and severity of tsunami. Impact could be lower or higher.	3 3 1 4 5 1-2 3	4 4 5 4 5 5 5
Natural Hazards	Severe Storms	Severe storms increase the likelihood of high stream turbidity and flooding, which puts drinking water quality at risk. The region has experienced impactful severe storms in recent years. December 2015 storms caused significant riverine flooding east of Highway 101. A combination of sand-blocking outlets and high tides meeting large volumes of runoff from the higher ground caused road closures. January 2021 saw coastal flooding events, landslides, and debris flows in the area. Climate change is projected to increase winter precipitation through more severe storms, which can increase erosion and sediment transport to streams.	These are common enough there should be some experience and knowledge on how to prepare and handle. Usually know these are coming and can prepare in advance. Already frequent enough that preparing for an dealing with these should already be occurring. It's about when it happens, not if. Storms are part of life on the Coast. The impact to drinking water will manifest as the topics discussed about, Landslides, Erosion. Impacts transportation infrastructure, etc., but maybe not drinking water intake & source area as much. Could affect power infrastructure which could affect drinking water supply. Storms are predictable by season and hit when demand is lower.	4 5 2 3 4 4-5 4	2 3 3 3 4 4 3

Risk Category	Risk	Description and Impacts	Comments/Questions	Risk Likelihood (scale of 1-5)	Risk Impact (scale of 1-5)
Natural Hazards	Wildfire	Wildfires remove vegetation and damage soils, which increases runoff and erosion and decreases soil water infiltration and retention. Firefighting chemicals could potentially impact water quality. Water used for fire suppression could be taken from the water supply. Increasing temperatures and droughts anticipated from climate change could increase the risk of wildfires.	<p>The majority of wildfires on the coast are human-caused (we could distinguish between natural and human-caused fires in DWPP).</p> <p>Concern of PFAS (not typically used for fire suppression). Not required to inform the state when PFAS is used for fires, but 13 occurrences have been reported statewide since 2020.</p> <p>Question about how we know about the 13 PFAS occurrences and request for more information about this. <i>Answer (from Alyssa): This number came from the DEQ Emergency Response Program –these were voluntary notices to the state when people used PFAS to extinguish fires. PFAS is not really used in the state for fires, but other types of foam.</i></p> <p>Wildfires in recent years were set off by extreme winds. Climate change could influence the causes of wildfires.</p> <p>High risk – fires always a concern in forests, whether human caused or natural.</p> <p>Not usual. Could be an increasing risk. Depends on location, severity, etc.</p> <p>Wildfire is a natural phenomenon and at some point in time there will be a significant fire. Likely in our lifetime fires will be small and low severity. There is a good, well maintained road system in Jetty Creek which will aid in any fire suppression activities and act as fire breaks. Accumulated slash piles from forest harvesting have been burned reducing the fire hazard. There will be little to no fire use associated with forest harvest in the next 18 years. Forest landowners have their own firefighting crews and contractors to aid in suppression of any future fires.</p>	<p>2 3 1 2 3 2-3</p> <p style="text-align: center;"><u>2</u></p>	<p>2 4 1-4 3 4 4</p> <p style="text-align: center;"><u>3</u></p>
Natural Hazards	Volcanic ashfall	Volcanic ashfall from a Cascade volcanic eruption is identified as a low risk to Lincoln County in the NHMP (2023) but could affect Rockaway Beach. The effects of volcanic ash would be significant for water quality and could damage water infrastructure (NHMP, 2023).	<p>Good to include but not necessarily something within the control of this plan/ a DWPP design?</p> <p>Can't control but could have a response plan just in case.</p> <p>I'm not sure if this is even a risk for Jetty Creek.</p>	<p>2 1 1 1 2 1-2</p> <p style="text-align: center;"><u>1</u></p>	<p>2 3 1 2 3 3-4</p> <p style="text-align: center;"><u>3</u></p>

Risk Category	Risk	Description and Impacts	Comments/Questions	Risk Likelihood (scale of 1-5)	Risk Impact (scale of 1-5)
Forestry Activities (See additional notes at end)	Clearcut harvesting	<p>The source watershed is 100% private forested land with two landowners (USWA, 2016). The USWA (2016) identified clearcut harvesting with a rotation of under 35 years as a potential risk in the source water area. The USWA specified clearcuts southeast of the City's intake as a risk. Aerial imagery from 2000 to 2024 shows that nearly the entire drinking water source area has been clearcut within the ~25 year time period.</p> <p>Timber harvesting impacts the ecology and hydrology of watersheds, including the amount of runoff, stream temperatures, sediment transport, soil properties and moisture retention, and stream turbidity (other DWPPs). Factors such as elevation, slope steepness, and direction of slope can influence the impact of timber harvesting. Jetty Creek has a history of erosion and sedimentation post-harvest). Additionally, younger age stands have been shown to reduce water in Jetty Creek during dry seasons.</p>	<p>Should clearcuts be a separate risk from partial harvesting/thinning?</p> <p>Could consider distinguishing between clearcuts near water intakes versus higher in the watershed due to potentially different impacts.</p> <p>Are risks different for longer rotation cycles? Could consider dividing out clearcutting risks by cycle length or other factors.</p> <p>Consider breaking the forestry section into risks/strategies for the lower watershed and upper watershed, based on the different landowners.</p> <p>Should be a distinct risk from thinning and partial harvesting.</p> <p>New PFA Rules will help in the longer term.</p> <p>Not as much thinning on the coast because of the high winds. Consider the size of clearcuts.</p> <p>Next 20 years will have more regrowth in forested land than clearcuts. Experiencing impacts of previous clearcuts even if they're not as likely in next 20 years.</p> <p>Water supply vs. sediment impacts will differ potentially (keep clearcutting as one category with discussion). Late season water supply potentially higher impact. Regrowth decreases streamflows.</p> <p>WTP has to be shut down during storms due to turbidity. Resiliency planning (shutting off WTP) mitigates risk currently. Fish screen also has to be shut down.</p> <p>20 year timeline is misleading for this risk, could make an addendum to this risk addressing a longer timeline.</p> <p>Comments that this should be a 5 for likelihood and have a higher impact</p> <p>Forest thinning could be a viable option - data shows</p> <p>Likelihood of thinning by current landowners (status quo) would be low but if the land ownership changes could change.</p> <p>If City owns watershed there would be a watershed management plan. This Plan focuses on risks assuming status quo w/ current landowners. Advisory Committee recommends a 5 for risk likelihood assuming the watershed stays under current ownership.</p> <p>In the past, City has had to shut down WTP because of high turbidity when clearcuts occur.</p> <p>Consider climate change as well</p>	<p>2 4 1 3 4 4-5 for clearcutting, 3 for non-clearcutting</p> <p>4 5 (Advisory Committee recommendation)</p>	<p>2 4 1-2 3 4 4 for clearcutting, 2 for non-clearcutting</p> <p>3-4 One thought was to align this with the score for erodible soils (4), but some team members thought the risk impact should be a 3.</p>

Risk Category	Risk	Description and Impacts	Comments/Questions	Risk Likelihood (scale of 1-5)	Risk Impact (scale of 1-5)
Forestry Activities	Pesticides (including herbicides)	<p>Pesticides, herbicides, and fertilizers used in forestry may enter waterways and contaminate water quality. DEQ has reported detections of herbicide residue (sulfometuron-methyl) in Rockaway Beach’s untreated drinking water (USWA, 2016).</p> <p>The method and timing of chemical applications influence the level of risk to drinking water. For example, applying on steep slopes in sparsely vegetated areas increases the risk of contaminating the creek. Aerial spraying is potentially a greater risk to water quality than other application methods. (other DWPPs)</p>	<p>Can we get soils tested and get a list of what sprays and chemicals have been used?</p> <p>Discuss herbicides in addition to pesticides and fertilizers in this section.</p> <p>Current landowners have been involved in conversation around adjusting pesticide and herbicide usage.</p> <p>MOU agreement restricts chemical use in the lower watershed. Pesticides and fertilizers are not typically used in the coastal forests. Fertilizers are not used in this watershed. Not doing spraying in lower watershed.</p> <p>Some risk but rules in place to minimize potential. Would likely take an unintentional circumstance to occur.</p> <p>FPA changes: increased notification of pesticide use, buffers.</p> <p>Herbicides are used following harvests (broadcast applications) and on roadsides typically (~3 year interval). 2013 was last aerial application. Differentiate aerial vs roadsides? Roadsides would have a lower impact. City is contacted & shuts off WTP when spraying happens.</p> <p>~12 mi of forest roads in Stimson portion of watershed</p> <p>Depends on distance from intake, if permits are followed, etc.</p> <p>Going to look into EPA testing for PFAS in pesticides.</p> <p>City tests water for pesticides at most annually (SOC test).</p> <p>There was a comprehensive testing program/study a few years ago on the Coast w/ Tillamook Estuary Partnership and most results were below <u>unsafe levels?</u></p> <p>This is an area where expertise matters a lot. Committee would benefit from a more in depth explanation. Would like a report from the Team justifying their score of 2 for risk impact.</p> <p>Advisory Committee recommends amending the risk likelihood of pesticides/herbicides to a 5.</p> <p>We don’t know what compounds might be used in the future and if any new chemicals with worse impacts could be used.</p>	<p>1 5 1 2 4 2-3</p> <p>4 <u>5</u></p>	<p>1 3 1-2 2 4 4</p> <p>2 <u>4 (Advisory Committee recommendation)</u></p>

Risk Category	Risk	Description and Impacts	Comments/Questions	Risk Likelihood (scale of 1-5)	Risk Impact (scale of 1-5)
Forestry Activities	Access Roads	Building, maintenance, and usage of roads, particularly wet weather haul, may contribute to erosion and stream turbidity. Updated Oregon Forest Practices Act rules and best management practices can help reduce these impacts.	<p>The access roads connect to other private forestry lands. Would the City be responsible for the maintenance of roads if it acquired land in the watershed?</p> <p>Depending on the easement structure, the roads would likely be 'user maintained' meaning those using the road would be responsible for the maintenance. Since the City would own the road, if acquired, they would be responsible for any maintenance not associated with user use.</p> <p>Could be higher impact depending on the circumstance.</p> <p>Updated FPA rules reduces this risk from "Likely" to "Possible"</p> <p>Depends on the location and road design.</p> <p>Roads in upper watershed don't seem to be down in floodplain. In good condition</p> <p>Forest Road Inventory Assessment part of FPA rules.</p> <p>Will any roads be built? Could that have different impacts? <i>Most infrastructure would be reused. Any new roads would have higher standards per new FPA.</i></p>	<p>2 3 1-2 2 3 4</p> <p style="text-align: center;"><u>2</u></p>	<p>2 2 1-2 2 3 3</p> <p style="text-align: center;"><u>2</u></p>
Forest Activities	Riparian Impacts	Timber harvesting activities could affect soils and vegetation along streams, resulting in increased erosion and stream turbidity. Reduced vegetation could lead to an increase in stream temperatures and potentially an increase in algae growth and bacteria counts. Updated Oregon Forest Practices Act rules increase riparian buffer zones based on stream classifications and add protections for non-fish-bearing streams.	<p>Less likely to be an issue going forward with new rules. Possibly some legacy impacts.</p> <p>Add invasive species- can use large amounts of water.</p> <p>Updated FPA rules reduces this risk from "Likely" to "Possible"</p> <p>It would be helpful to know which of the streams would fall into fish and non-fish bearing and therefore the PFA levels they qualify under.</p> <p><i>Timber harvesting increases likelihood of blowdown.</i></p> <p><i>Other impacts such as invasive species</i></p>	<p>1 3 1 2 3 3</p> <p style="text-align: center;"><u>2</u></p>	<p>1 3 1 2 3 2</p> <p style="text-align: center;"><u>2</u></p>

Rockaway Beach Source Water Protection Plan Risks Prioritization Table (Surface Water)

Risk Category	Risk	Description and Impacts	Comments/Questions	Risk Likelihood (scale of 1-5)	Risk Impact (scale of 1-5)
Forestry Activities	Borrow Pit	A small, likely inactive (identified as inactive in the 2002 SWA) borrow pit east of the intake used for local logging roads is a potential risk to drinking water. Spills or leaks of waste or chemicals from mining operations could impact water quality (SWA, 2002).	<p>The original SWA (2002) describes the borrow pit as small and inactive.</p> <p>Comment in June 17 SPPDAC meeting that there is an active borrow pit. Is the active borrow pit in the watershed or outside of it? Which pit is active? There are a lot of trucks going up and down access roads that may or may not be in Jetty Creek Watershed.</p> <p>Get information on where the active pit is from the landowners. City can start identifying on future maps where the active borrow pit is (potentially in the DWPP map).</p> <p>Several potential pits visible in aerial imagery and lidar. Better understanding of number, locations and current/potential use is needed.</p> <p>Single source easier to take measurements to reduce potential problems.</p>	<p>1 2 1 2 Not Enough Information to Characterize 1-2</p> <p style="text-align: center;"><u>1</u></p>	<p>1 2 1 2 Not Enough Information to Characterize 2</p> <p style="text-align: center;"><u>1</u></p>
Municipal	Infrastructure leakage or failures	Municipal water system infrastructure, such as pipes, valves, storage tanks, and water treatment facility, is vulnerable to leaks and failures due to aging and wear and tear. Aging infrastructure may impact the City's ability to divert, store, and distribute water. Leaks can increase demand for water diversions, which may not be available during droughts.	<p>This issue is being addressed. The City has an active leak detection program in the budget, and is working to replace mainlines (specifically at Nedonna Beach).</p> <p>This is outside the watershed.</p> <p>Should look at any and all ways to increase efficiency</p> <p>In 2010 there was a significant amount of water loss due to leaks. I'm not sure how much there is now. As infrastructure ages leaks will increase.</p>	<p>3 2 3 3 2 3</p> <p style="text-align: center;"><u>3</u></p>	<p>4 2 2-3 3 3 5</p> <p style="text-align: center;"><u>5</u></p>
Municipal	Vandalism	Vandalism or sabotage would include deliberate damage to water pipelines, the water treatment facility, and other components of water infrastructure. Vandalism could impact water quality or quantity. Cybersecurity is another concern for municipalities, as cyber attacks could affect the City's ability to operate its water system.	<p>Cybersecurity seems like a higher risk than deliberate physical damage.</p> <p>Impact could be higher depending on circumstance, such as cyber attack.</p>	<p>1 3 1 2 1 2</p> <p style="text-align: center;"><u>2</u></p>	<p>4 3 1 3 4 1</p> <p style="text-align: center;"><u>4</u></p>
Municipal	Development	New development will add to water demand. Ensuring the City will have an adequate water supply is a growing concern.	<p>Information, such as projections for climate scenarios and development etc, would help with understanding whether the City has sufficient water supply.</p> <p>Need to take steps to plan for additional need. Increase efficiency, look to alternative sources (desalination?)</p> <p>Development will increase water demand. It seems during August and September there is already more demand than can be supplied during dry years. If that increase causes overuse of the wells that have had problems with salinity coliform and organic compound. That could be a risk to the water source.</p> <p>Some potential development planned by City.</p>	<p>4 3 2 3 3 3-4</p> <p style="text-align: center;"><u>4</u></p>	<p>3 2 2 4 3 4</p> <p style="text-align: center;"><u>4</u></p>

Rockaway Beach Source Water Protection Plan Risks Prioritization Table (Surface Water)

Risk Category	Risk	Description and Impacts	Comments/Questions	Risk Likelihood (scale of 1-5)	Risk Impact (scale of 1-5)
Municipal	Tourism	Tourism increases water demand substantially in the summer. Ensuring the City will have an adequate water supply to meet summer demand is a growing concern.	Information, such as projections for climate scenarios and development etc, would help with understanding whether the City has sufficient water supply. Usage rates throughout the year would be helpful to see. Probably similar to development. The challenges with water supply peak with peak tourism at the end of summer. Tourism has become more year-round with short-term rentals. Hasn't affected summer supply based on winter storage.	4 4 3 3 3 4 4	3 3 2 4 3 2-3 <u>4</u>
Land Use	Unauthorized camping	Camping is not allowed on the properties within the watershed, but it can be difficult to prevent people from accessing and camping on the land. Camping land uses that pose a risk to the source watershed include improper garbage and/or human/animal waste disposal, potential vehicular pollution, and fires.	We could include these risks under the municipal category, or create a separate category (such as land use). Could be part of a recreational risk section Not likely to happen on large scale but could occur to some degree. Could offer alternate sites that are more controlled. Especially if homeless crisis expands to other areas like observed in places such as Seaside, OR	3 3 1 2 2 2 <u>2</u>	2 2 1 2 3 2 <u>2</u>
	Recreation	Hiking, horseback riding, and possibly other recreational uses in the source water area pose potential risks to drinking water, such as erosion and pollutants from litter and/or animal waste.	Low amount of use limits impacts and risk.	1 3 1 2 3 4 <u>2</u>	1 2 1 2 2 1 <u>1</u>

DRAFT

General questions and comments

- Time frame? What time frame are we using? Given enough time all these will occur at their most severe intensity.
- It seems there are primary and secondary risks. Most of the forest management activities are secondary that they may exacerbate the primary. Might combine categories?

Additional Forestry Comments

Clearcut Harvesting

The explanation in the description/impacts tab describes potential impacts assuming no rules or BMP's are followed. Because of Oregon's FPA rules and BMP's paired watershed studies such as the Trask and Alsea indicate that direct impacts from harvests are short term and not biologically significant.

Jetty Creek would have been 100% Harvested and likely broadcast burned in the 1950's-60s with no riparian buffers. It is possible that more of the old growth was harvested at an earlier interval. 2010's to present harvest began again under FPA rules and significantly better techniques and technologies.

Average age of Clearcut in West Oregon 40-50 years. Jetty Creek harvest age is older, the last stand we harvested was 56.

There will be no harvesting on Stimson ground for at least 18 years within Jetty Creek.

When does a clear-cut become a young-forest? Currently the youngest stand has 6 year old trees in it and is fully occupied by trees and early seral vegetation. (2 year old trees are replanted). The oldest harvest is 22 years old.

I would argue that thinning can have more risks to cause sedimentation than clearcuts. Thinning often requires more roads to reach around leave trees and leave areas. Thinned stands are more susceptible to strong winds and expose soil when they blow over and uproot.

Mentioned low flow impacts of harvesting under low flow/ drought section

Pesticides, Herbicides, and Fertilizers

An herbicide is a pesticide, it's confusing to list them separately.

There is no operational practice for fertilizing hemlock stands.

Historically herbicides, insecticides, and rodenticides are the only pesticides associated with forest activities. Insecticides are rarely if ever used currently. Rodenticides are associated with control of mountain beavers and are used very little. Herbicides are commonly used in forestry.

In a typical rotation herbicides are used 1-2 times in 40 to 50 years. Herbicides must meet certain criteria by the EPA to be registered for forestry use. They target biological process such as photosynthesis that are unique to plants, thus they are relatively non-toxic to birds and mammals. most of the products commonly used in forestry are in the class 4 relatively nontoxic category. For comparison dawn dish soap would fall in this category, Table salt is a class 3 slightly toxic, Caffeine is Class 2 moderately toxic. (Acute oral exposure)

There are several studies local to the area looking into forestry related herbicide use and drinking water. DEQ did a study around 2013-2014 along the coast, more recently needle branch part of the Alsea watershed, and Stimson hired a 3rd party to conduct a study in the Tillamook Watershed. These studies are under the old FPA

rules. The new rules significantly increased protections of water. In these studies herbicides were sometimes detected at extremely low levels, for short durations within 24 hours of application, immediately adjacent to the application site. They were 100 to 1,000 of times below the MCL for chronic exposure. So, in summary nowhere near a level for health concern for a very short period. Several of these were done with aerial applications.

There likely won't be any broadcast herbicide applications on Stimson forestland in Jetty Creek in the next 18 years. There will be a roadside herbicide application on a 3-4 year cycle. During roadside applications roads are surveyed ahead of time and streams/ wet areas are flagged with a 10' to 50' buffer depending on water type. The water district is also notified ahead of time so that they can shut off the intake during the operation.

I am not aware of a water system ever getting a detection of herbicides over a MCL.

Access Roads

The biggest potential for impact from forest harvest activity will be from roads at stream crossings during high rainfall events. A recent paper from the Trask watershed showed detectable increase in sediments from roads beneath stream crossings but, not at a biologically significant level when following FPA rules and best management practices. The new FPA rules increase protections and infrastructure requirements for roads and stream crossings which should reduce impacts further. Jetty creek has some of the best rock there is to maintain roads, and the infrastructure is up to date and in good health. Foresters routinely survey road surfaces and infrastructure during and after harvest to make sure they are functioning properly. Culverts are surveyed during high rainfall events in an effort to locate and remove any blockages due to slides and high stream flows. FPA rules require structures be built to withstand 100 year flood events. Log hauling and truck traffic is halted during high rain fall events. Usually around 1.5" in 24 hours. Cross drains and road surfaces are designed to direct water away from stream systems so that it can filter through the forest floor.

Riparian Impacts

New FPA buffers require 100'-110' either side of fish streams and 50'-75' buffers to non-fish perennial streams. All other streams have protections from equipment activity. The buffer width is to ensure protection of cold water habitat and from sedimentation. Vegetation on the coast grows rapidly, any riparian area exposed to sunlight will be covered in salmonberry/elderberry within 1-2 years. The biggest impact from riparian areas will be trees uprooting during windstorms and exposing soil near the stream system.

Rockaway Beach DWPP Risks to Groundwater

7/22/2024

Identifying and prioritizing potential risks will form the foundation for developing strategies to protect drinking water quality. Risks can be prioritized based on the likelihood of their occurrence and the severity of their impacts to drinking water sources, water quality, and infrastructure. Using a scale of 1-5, please indicate how you would rate these two aspects for each risk below.

Likelihood		Impact	
1	Rare/very unlikely	1	Insignificant
2	Unlikely	2	Minor
3	Possible	3	Moderate
4	Likely	4	Severe
5	Almost certain	5	Catastrophic

Risks to Groundwater Sources

Risk Category	Risk	Description and Impacts	Comments/Questions	Input on Risk Likelihood (scale of 1-5)	Input on Risk Impact (scale of 1-5)
Natural Hazards ¹	Tsunami	Rockaway Beach is at a higher risk of a tsunami than Tillamook County as a whole (NHMP, 2023). The water treatment plant and public works building are exposed to tsunami (CSZ M9.0-med) and have a greater than 50% probability of moderate to complete damage from a CSZ earthquake (NHMP, 2023). A tsunami could destroy vital infrastructure and result in water supply shortages, potential saltwater intrusion, and other contamination of drinking water.	<i>Could be higher depending on location, at least to the infrastructure. Not sure that it would affect groundwater itself.</i>	3 3 3 5	4 4 3 5
Natural hazards	Saltwater intrusion	OHA has issued at least three alerts of sodium detections in the City's groundwater (USWA, 2016). Sodium from seawater impacts water quality. In addition to introducing salt, seawater can transport other pollutants to groundwater. With sea level rise due to climate change, this risk is likely to increase.	<i>Have more alerts been issued since 2016?</i> <i>Might be more of a developing issue for planning purposes</i>	3 4 3 4	3 4 2 3
Municipal	Sewer lines	Sewer lines through residential areas pose a contamination risk to groundwater.	<i>Stresses the importance of maintenance of sewer and water lines.</i>	3 3 3 3	3 3 2 4

Risk Category	Risk	Description and Impacts	Comments/Questions	Input on Risk Likelihood (scale of 1-5)	Input on Risk Impact (scale of 1-5)
Municipal	Septic systems	Above ground storage tanks and large capacity septic systems serving more than 20 people are potential sources of contamination. Septic systems, particularly aging ones, can leach contaminants into the groundwater.	<i>Can be monitored and corrected. Stresses importance of maintenance.</i>	3 3 3 3	3 2 2 4
Municipal	Residential high-density housing	High-density housing with septic systems can result in a higher concentration of contaminants leaching into groundwater these areas.	<i>Should this be a separate risk from the septic systems risk?</i> <i>Can limit additional developments of this nature. Also maintain systems to prevent intrusion.</i>	3 3 3 3	3 3 2 4
Municipal	Aging infrastructure	Aging wells, pipelines, and other components of drinking water infrastructure put the ability of providing groundwater at risk.	<i>This issue is being addressed. The City has an active leak detection program in the budget, and is working to replace mainlines (specifically at Nedonna Beach).</i> <i>Need to address sooner than later. Costs will keep rising. If this is an important water source it will be worth the investment.</i>	3 3 3 2	3 3 3 3

Risk Category	Risk	Description and Impacts	Comments/Questions	Input on Risk Likelihood (scale of 1-5)	Input on Risk Impact (scale of 1-5)
Municipal	Dike	A dike between Nedonna and the Nehalem River has likely not been maintained in several years, which could put groundwater quality at risk if the dike failed.	<p><i>Potentially need more information about the dike to identify risk level</i></p> <p><i>Also need more info on groundwater source in this area. Will tides reach it if the dike is breached? Can it be moved? Potential natural resource benefits from removal/breaching</i></p>	<p>3</p> <p>3</p> <p>3</p> <p><i>Not enough information to characterize</i></p>	<p>2</p> <p>2</p> <p>2</p> <p>3</p>
Municipal	Phone line?	SFM (State Fire Marshall) - HSIS (Hazardous Material Information System) for WIRED TELECOMMUNICATIONS CARRIERS has one chemical reported on site that could impact water quality	<p><i>Information is lacking about this risk. USWA doesn't identify the chemical that poses a risk.</i></p> <p><i>Seems low risk. Any record of this being an issue anywhere?</i></p>	<p>1</p> <p>2</p> <p>3</p> <p><i>Not enough information to characterize</i></p>	<p>2</p> <p>1</p> <p>1</p> <p><i>Not enough information to characterize</i></p>

Risk Category	Risk	Description and Impacts	Comments/Questions	Input on Risk Likelihood (scale of 1-5)	Input on Risk Impact (scale of 1-5)
Transportation	Roads, highways, and railroads	<p>Several transportation corridors as potential risks to groundwater sources: the Port of Tillamook Bay Railroad, Highway 101, and a few roads owned by BLM, ODOT, the City, and the County.</p> <p>Vehicles may deposit contaminants that can infiltrate into groundwater sources via stormwater runoff.</p> <p>Herbicide use along highways, roads, and railroads has also been identified in the groundwater source area, which could potentially contaminate groundwater.</p>	<p><i>Less restrictions are placed on chemical use for municipal infrastructure ROW than forestry use.</i></p> <p><i>This is already in place. Are there major issues? Can implement strategies to minimize (bioswales, others?)</i></p>	<p>3 2 3 3</p>	<p>3 3 2 3</p>
Industrial	Mercury storage site	<p>Mercury is stored at a site uphill from Nedonna Beach, posing a risk to the groundwater in Nedonna Beach if there is a Mercury leak</p>	<p><i>Potentially need more information about the Mercury storage site to identify risk level</i></p> <p><i>Need to know more. Also, is this something that is necessary or could be relocated?</i></p>	<p>3 3 3 <i>Not enough information to characterize</i></p>	<p>3 2 2 4</p>

Risk Category	Risk	Description and Impacts	Comments/Questions	Input on Risk Likelihood (scale of 1-5)	Input on Risk Impact (scale of 1-5)
Other	Stormwater	The USWA identified stormwater from Nedonna Wave PUD (People's Utility District?) as a potential source of pollution in its Site Information System (SIS). Stormwater runoff is a risk to groundwater quality, as it has the potential to transport pollutants to the groundwater.	<p><i>More information is needed about this specific risk.</i></p> <p><i>Could be higher depending on the circumstance. Why single out PUD-stormwater runoff comes from a lot of sources.</i></p>	<p>3</p> <p>2</p> <p>3</p> <p><i>Not enough information to characterize</i></p>	<p>3</p> <p>2</p> <p>2</p> <p>3</p>

¹Other natural hazards risks from the surface water risks table may apply to groundwater, such as highly erodible soils, landslides, and wildfires, but weren't included in this table to minimize repetitive information.

**PUBLIC TESTIMONY
SUBMITTED FOR
JULY 29, 2024
SPPDAC MEETING**

From: nancy webster <[REDACTED]>

Sent: Monday, July 29, 2024 6:45 AM

To: ron clemen <[REDACTED]>; Alesia Franken <[REDACTED]>; Jay Udelhoven <[REDACTED]>; lydia hess <[REDACTED]>; Jason Maxfield <[REDACTED]>; s.l.johnson <[REDACTED]>; charlesmcneilly <[REDACTED]> City Hall <cityhall@corb.us>

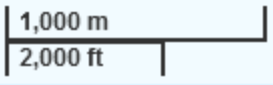
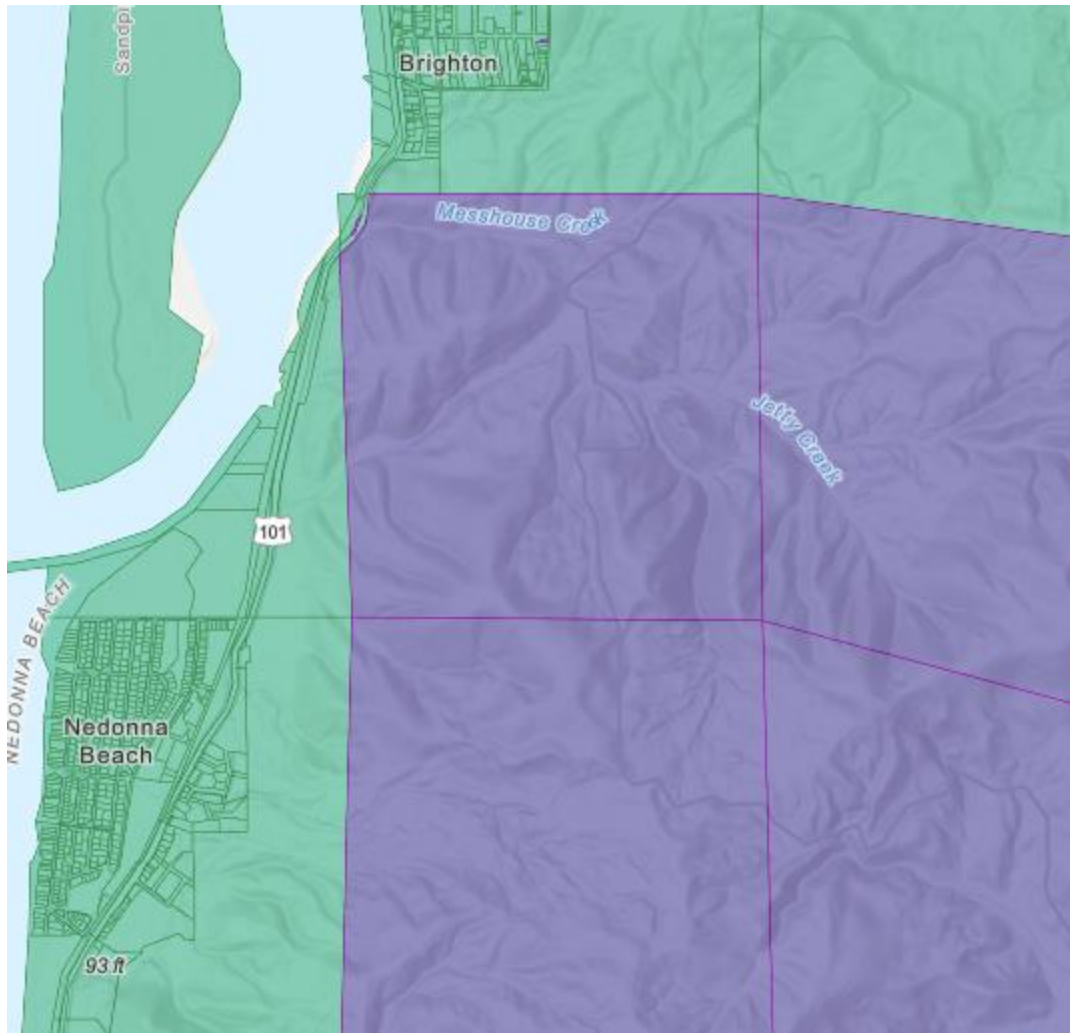
Cc: nancy webster <[REDACTED]>

Subject: Wildfire Risk Levels: Submitted to SPPDAC July 29th 2024

Rockaway Beach Source Water Protection Plan Risk Prioritization Table (GSI.)




I question the accuracy of the stated wildfire risk for the Jetty Creek watershed. The stated risk is "2 or low." See below for my justifications for questioning this low risk for wildfires.

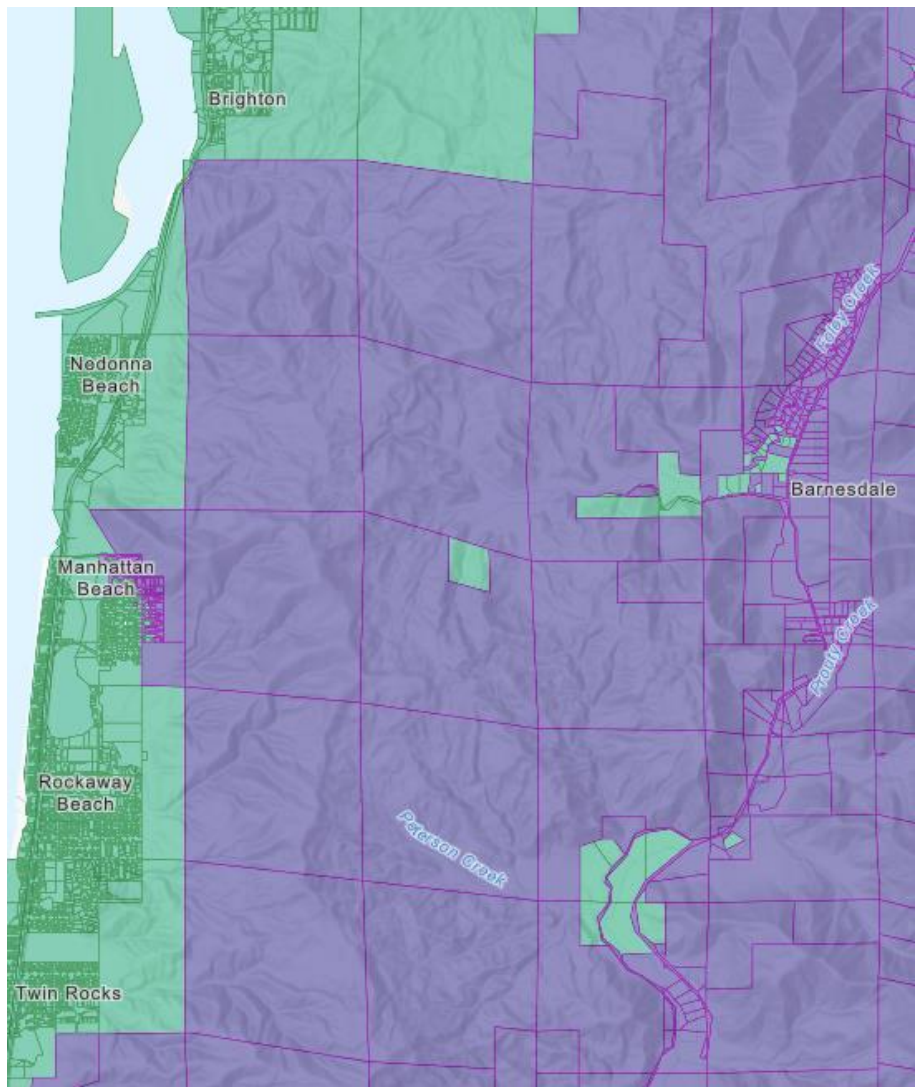
1. Overall, the current State fire maps show the Jetty Creek watershed as a "moderate fire risk." Please see tables below.
2. Conifer tree plantations burn hotter than natural forests that are of a mixed age and type of trees, having both deciduous trees (such as alders) and conifers. (Professor Beverly Law from Oregon State University) Alder trees can become fire breaks. (Research from Canada and U.S.)
3. In the last twelve years, North Coast Communities for Watershed Protection members have observed a number of wildfires resulting from slash pile burning after logging on tree plantations in Tillamook and Clatsop Counties.
4. NCCWP has observed wildfires above Short Sand Beach resulting from aerial spraying of "Easy Light" (Napalm) after logging.
5. Those of us living in the Nedonna Beach neighborhood have concerns that fires starting in the private forestland east of us could easily jump Highway 101. Our sem-forested neighborhood could easily go up in flames, and there is only one exit to the highway for all 370 houses. But still more housing is proposed to be built in our neighborhood. Conversely, a major fire in this neighborhood could easily cross Highway 101 to the privately-owned forestlands. The Nedonna Beach neighborhood is defined by DEQ as a source drinking water protection area for the groundwater backup wells for Rockaway Beach.



ESRI, NACA, NCA, USGS, FEMA, LG

Statewide Wildfire Hazard Map

-  Low Hazard
-  Moderate Hazard
-  High Hazard



Thank you.
Nancy Webster
Nedonna Beach Neighborhood
P.O. Box [REDACTED]
Rockaway Beach, Oregon
Phone: [REDACTED]

Sent: Monday, July 29, 2024 7:02 AM
Subject: New message from SPDAC Comment Form
Attachments: 66a7a0c9a01c4.pdf

Nancy Webster
POB [REDACTED] Rockaway Beach Oregon 97136
[REDACTED]

More Information on Pesticides Submitted to SPPAC 7-29-24

Rockaway Beach Source Water Protection Plan Risk Prioritization Table.

Let's take a closer look at the pesticides being sprayed in both our surface and groundwater DEQ protection areas. Pesticides have been used regularly in the "tree plantation" that the Jetty Creek watershed (primary source for RB drinking water) has become. Pesticides are also being used by homeowners and others in Nedonna Beach, which is within the DEQ groundwater protection area (location of City backup wells). Potentially, we are exposed to harmful pollutants through the air we breathe and the water we drink according to DEQ, OHA, and EPA.

Here is more information from toxicologist, Dr. Deke Gundersen, Professor Emeritus of Environmental Science at Pacific University. Since 2015, North Coast Communities for Watershed Protection has been consulting with Dr. Gundersen about public and habitat health concerns regarding the spraying of pesticides. NCCWP recently asked Dr. Gundersen for an update about research on the pesticides being sprayed on industrial forest land. On June 22, 2024, Dr. Gundersen spoke at an NCCWP forum.


Shown in italics below is an email from Dr. Gundersen:

Basically, the safety of Roundup and other pesticides cannot be confirmed, because very little testing has been done on the FORMULATIONS. However, recent studies on HUMAN CELLS are showing that the toxicity of the formulation (e.g. Roundup) is much more toxic (in some cases 1000 times more toxic) than the pure compound (e.g. glyphosate) on human cells. We know nothing about the effects of pesticide mixtures (e.g. Roundup + 2,4-D, + triclopyr) on humans. Here are links to the articles I talked about in my presentation on June 22. Just focus on the information in the abstract (a good summary of the paper). <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9699558/> <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3955666/pdf/BMRI2014-179691.pdf> <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4808927/> <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5786549/> This is a great article on the toxicity of formulations: <https://www.theguardian.com/business/2020/jan/23/formulations-glyphosate-based-weedkillers-toxic-tests#:~:text=Anotherinternalemailwrittenin,doesthedamage.> Monsanto emails showing they have not tested the formulation: <https://www.wisnerbaum.com/documents/pdf/monsanto-documents/27-internal-monsanto-email-you-cannot-say-that-roundup-is-not-a-carcinogen.pdf> <https://corporateeurope.org/sites/default/files/attachments/37-monsanto-executive-admits-studies-demonstrate-formulated-roundup-does-the-damage.pdf> I have also attached a review

article discussing the impacts of pesticides on the forest microbiome. I hope all of this is useful to you. Thanks for all you do. Deke
Submitted by Nancy Webster

Opinion

Ecosystem consequences of herbicides: the role of microbiome

Suvi Ruuskanen ^{1,2,*} Benjamin Fuchs,³ Riitta Nissinen,¹ Pere Puigbò,^{2,4,5} Miia Rainio,² Kari Saikkonen,³ and Marjo Helander²

Non-target organisms are globally exposed to herbicides. While many herbicides – for example, glyphosate – were initially considered safe, increasing evidence demonstrates that they have profound effects on ecosystem functions via altered microbial communities. We provide a comprehensive framework on how herbicide residues may modulate ecosystem-level outcomes via alteration of microbiomes. The changes in soil microbiome are likely to influence key nutrient cycling and plant–soil processes. Herbicide-altered microbiome affects plant and animal performance and can influence trophic interactions such as herbivory and pollination. These changes are expected to lead to ecosystem and even evolutionary consequences for both microbes and hosts. Tackling the threats caused by agrochemicals to ecosystem functions and services requires tools and solutions based on a comprehensive understanding of microbe-mediated risks.

Microbes in the Anthropocene

Overexploitation and chemicalization are major drivers of accelerating biodiversity loss – one of the greatest global threats to functions and services in natural and agricultural ecosystems [1]. The heavy use of agrochemicals, such as **herbicides** (see [Glossary](#)), plays a critical role in the contamination, exposing non-target plants, animals, and humans [2]. While many herbicides were initially considered safe for **non-target taxa** as their mechanism of action was thought to be absent in these organisms, it has been understood only recently that herbicides may have profound effects on non-target taxa via alterations of microbial communities and microbial function in soil, plants, and animals [3,4] ([Table 1](#)). Given the imperative role of microbes in driving ecoevolutionary adaptations since the origin of life, and that microbes and their hosts comprise coevolving, multipartite entities, holobionts [5], a comprehensive understanding of the risks associated with altered **microbiomes** is needed [6]. Here, we propose that herbicides can influence natural and agricultural ecosystem functioning due to soil- and host-associated microbiome alteration ([Figure 1](#)) and may have evolutionary consequences. Further, we discuss the limitations in the current literature to address these questions. We focus mainly on terrestrial ecosystems where herbicides are intended to be used, although agrochemicals are known to escape to aquatic environments as well [7]. We address ecosystem processes from molecular biology through physiology to ecological and evolutionary ecosystem processes. Thus, our Opinion, providing a conceptual framework on how sublethal herbicide residues modulate ecological and evolutionary changes in ecosystems, is important to fundamental ecological understanding as well as to applications in agroecological and environmental management.

Risks of herbicides: global habitat contamination

Global herbicide usage has increased drastically over the past decades, with 1 Mt used every year [8]. Glyphosate is globally the most-used herbicide [9]. Glyphosate is used in agriculture, but, importantly, also in horticulture, silviculture, and urban environments [9], leading to global

Highlights

Microbes have driven ecoevolutionary adaptations since the origin of life and maintain the welfare of ecosystems today.

Global contamination with herbicides, initially considered safe for non-target taxa, is shown to influence soil, plant, and animal microbiomes.

Changes in microbiomes can have unforeseen effects on organismal and ecosystem functioning and have evolutionary consequences.

A comprehensive understanding of the risks associated with agrochemical-altered microbiomes is needed.

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contamination of manmade and natural ecosystems. Other widely used herbicides are, for example, triazines (e.g., atrazine), acetochlor and metolachlor, paraquat, and dicamba [8,10] (Table 1). Residues of herbicides are found in soil, water, non-target plants, animals, and humans [3]. In addition to **active ingredients**, commercial herbicides include **co-formulants**, which can be even more toxic to non-target organisms (Box 1). Herbicides can have non-microbiome-mediated effects on non-target plants and animals, but the effects via altered soil and host-associated microbes are less understood and therefore are our focus.

How herbicides affect microbes and microbial communities

The effects of herbicides on soil- and host-associated microbes can be either (i) **direct**, influencing microbe **function and survival** or (ii) indirect, via the environment or host, depending on the mode of action of the herbicide [4] (Table 1). Glyphosate can influence microbial survival directly as it inhibits the enzyme **5-enolpyruvylshikimate-3-phosphate synthase (EPSPS)** of the **shikimate pathway**, which produces essential amino acids in both plants and the majority of microbes [15]. Other herbicides directly inhibiting microbial metabolic processes include **acetolactate synthase (ALS)** inhibitor herbicides altering the biosynthesis to branch-chained amino acids, **acetyl-CoA carboxylase (ACC)** inhibitors interfering with fatty acid synthesis, and glutamine inhibitors interfering with nitrogen metabolism [4]. In another group of herbicides, the mode of action does not directly target microbes but targets plant cellular metabolism, such as photosynthesis and plant hormone biosynthesis. Any changes in plant traits, however, can alter the microbiota interacting with plants [16]. Herbicide exposure can ultimately change microbial communities via multiple processes [17] (Figure 1). (i) Microbes differ in their intrinsic susceptibility to herbicides. For example, certain amino acid markers determine the affinity of glyphosate for the target enzymes and thereafter the microbial sensitivity [18,19]. Differences in microbe sensitivity can lead to changes in their abundance under herbicide exposure. (ii) Many microbes can metabolize herbicides and use them as sources of nutrients. Examples include atrazine and glyphosate, which are metabolized by *Pseudomonas* and *Arthrobacter*, acetochlor and dicamba metabolized by *Sphingomonas*, and paraquat metabolized by *Lipomyces* yeast [20]. Therefore, herbicide residues can increase the abundance of herbicide-metabolizing microbes in the community. (iii) Herbicides can cause functional changes in microbes that could cascade to community effects. (iv) All of the abovementioned alterations can further alter microbe–microbe interactions. Healthy microbial communities are able to maintain potential for self-regulation in the long term [21]. Thus, changes due to herbicide exposures can negatively impact community functionality.

Consequences of herbicide residues for soil processes

Soil- and **rhizosphere**-associated microbes are essential for the capacity of soil to support vital ecosystems. The consequences of herbicide use for soil processes depend on the herbicides' chemical composition, their mode of action, and the microbes' susceptibility to them, as well as edaphic factors and climate. The fate of herbicide and its legacy in soil are difficult to predict because they depend on multiple and/or partly counteracting forces; herbicides affect microbial communities and microbes degrade herbicides, and two processes can be interactively determined by the physical and chemical characteristics of the soils, agricultural management practices, and climatic conditions. Accordingly, the findings on herbicide effects on soil microbiomes have been variable [7,44]. For example, glyphosate (active ingredient) negatively affects shikimate pathways present in the majority of microbes, but their genetic resistance to glyphosate varies [18]. Therefore, some of the resistant and glyphosate-degrading microbes that can use glyphosate as a nutrient source may become prevalent in the microbial community [26]. Similarly, in some environments atrazine may not affect the overall microbial community ([45]; active ingredient), while in other environments it can decrease soil microbial biomass or increase atrazine-degrading bacteria ([46,47]; active ingredient) due to strong selection favoring them, thus leading to atrazine degradation.

Glossary

5-Enolpyruvylshikimate-3-phosphate synthase (EPSPS):

enzyme that is inhibited by glyphosate in many microbes.

Acetolactate synthase (ALS): some herbicides inhibit this enzyme pathway also in microbes.

Acetyl-CoA carboxylase (ACC): some herbicides inhibit this enzyme pathway also in microbes.

Active ingredient: chemical element or compound in a herbicide having specific effects on plant metabolism resulting in plant death.

Co-formulants: non-active ingredients in herbicides to increase the efficiency of the product. For example, surfactants are added to reduce surface tension, increasing the emulsifying, spreading, dispersibility, and wetting properties of the liquid.

Herbicide: plant protection product that is used to eradicate undesired plants.

Microbiome: microorganisms (bacteria, archaea, fungi) and their genes in a particular habitat.

Mycorrhiza: symbiotic association between a plant root and a fungus.

Non-target taxa: microbe, plant, or animal species that are not targeted with a herbicide.

Phyllosphere: aboveground plant surfaces; the largest biologically active surface on Earth, plant–atmosphere interface, and habitat for diverse microbes.

Rhizosphere: soil surrounding plant root impacted by plant root exudates and associated microbiota.

Table 1. Examples of studies on the effects of herbicides with different modes of action on soil, plant, and animal microbiomes^a

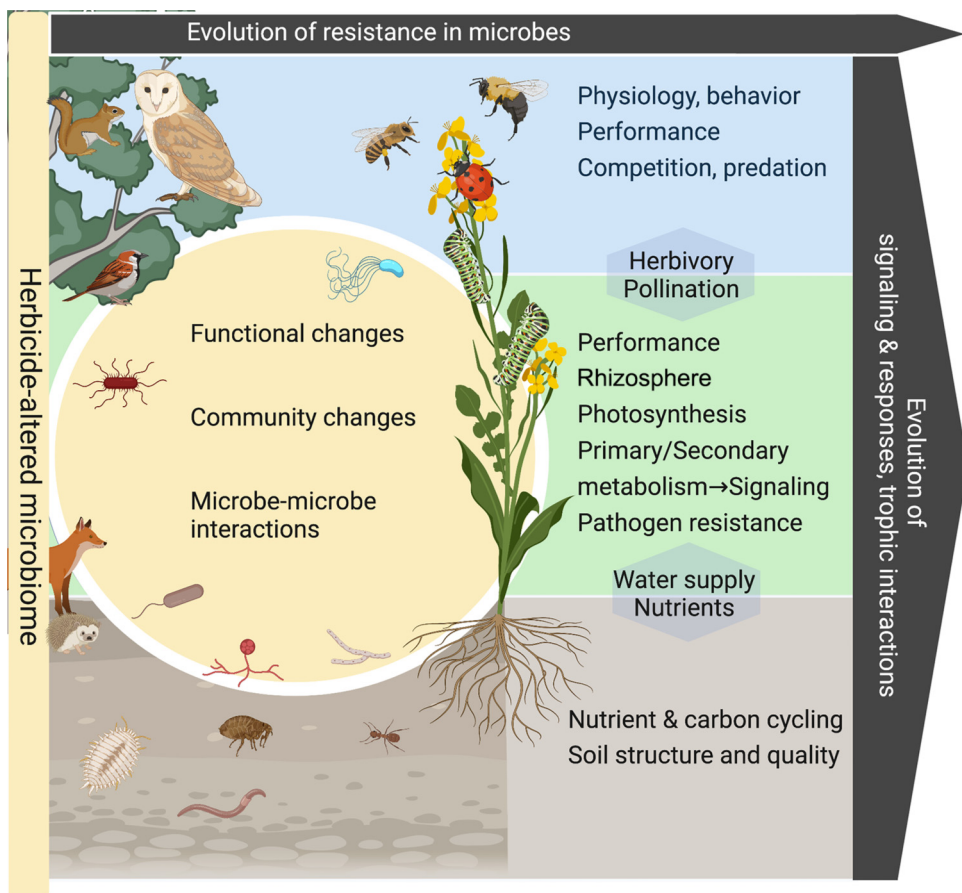
	Herbicide class/model of action	Example of chemical	Effect on microbiome		
			Soil	Plant	Animal
Direct effect on microbes	ACC inhibitors	Diclofop, haloxyfop	Composition, including Sulfur-cycling-associated bacteria [22] F	Rice, <i>Oryza sativa</i> [23] A	–
	ALS inhibitors	Sulfonylureas, imidazolinones, triazolopyrimidines	Community composition [24] A	<i>Arabidopsis</i> [25] A	–
	EPSPS inhibitors	Glyphosate	Microbial functions [26] AF	<i>Arabidopsis</i> [27] A	Japanese quail <i>Coturnix japonica</i> [28] F
	Glutamine synthetase inhibitors	Glufosinate	Community functional response [29] A	Oilseed rape <i>Brassica napus</i> [30] F	Mouse <i>Mus musculus</i> [31] A
Indirect effect on microbes	Auxin-like herbicides	2,4-D, aminopyralid, dicamba	Bacterial diversity [32] F	Rice <i>Oryza sativa</i> <i>L. japonica</i> [33] A	Mouse <i>M. musculus</i> [34] A
	Photosystem II inhibitors	Triazine herbicides	Community structure [35] A	Millet <i>Pennisetum americanum</i> [36] A	Black spotted frog <i>Pelophylax nigromaculatus</i> [37] A
	Photosystem I inhibitors	Bipyridinium herbicides (e.g., diquat, paraquat), diphenyl ether	Nitrogen-fixing bacteria [38] F	Rice <i>O. sativa</i> [39] F	Mouse <i>M. musculus</i> [40] A
	Gibberellin inhibitors	Acetochlor, metolachlor, pendimethalin	Composition, nitrogen-fixing bacteria [41] A	Wheat <i>Triticum aestivum</i> [42] A	Ground beetle <i>Pterostichus melas italicus</i> [43] F

^aThe first four have a mode of action with direct antimicrobial effects, while the latter four affect plant traits, and therefore microbes only indirectly. Our aim is to demonstrate the breadth of microbial processes affected and provide examples across taxa when available, but also to point to missing information in the literature, to our knowledge (marked –). We have further provided information on whether the study used an active ingredient (**A**) of the herbicide or a commercial formulation (**F**).

The potential ecological and evolutionary consequences of glyphosate and other herbicides for microbial soil communities are insufficiently understood [19,48]. Nevertheless, recent studies indicate a negative correlation between pesticide use and beneficial soil- and root-associated microbes ([12,49,50]; active ingredient and commercial formulation) and herbicide-modulated nutrient cycling in soils [13]. For example, the glyphosate molecule contains phosphorus (P) that adds an extra P load to the ecosystem [13]. In addition, herbicides may further affect soil P cycling by competing with phosphate ions for the same binding sites. However, the outcome of this glyphosate–phosphorus interaction in the soil again depends greatly on the soil properties and biotic factors (vegetation type and soil microbial communities), as well as climate and weather conditions.

Consequences of herbicides on plant–microbe and plant–animal interactions

Herbicide residues may affect a plant and its associated microbes, either individually or in concert as a metagenomic unit. The consequences of sublethal herbicide doses, especially glyphosate, for soil processes are now increasingly recognized, but the effects on plant associated microbiota, plant physiology and subsequent consequences for species interactions remain poorly understood (Figure 1). The negative impact of glyphosate (active ingredient and formulations) on root infectivity, colonization, and the arbuscule density of arbuscular mycorrhizal fungi (AMFs) has been repeatedly observed [13,14,49,51]. This has consequences for the water and nutrient economy of plants and may also impact AMF diversity and ecosystem functioning [14]. Far less is known about the impacts of herbicides on ectomycorrhizal fungi, although the majority are potentially sensitive to glyphosate [18] and are known to play a key role in boreal and taiga forest ecosystems. As root-associated



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Figure 1. Consequences of herbicides for plant-microbe and plant-animal interactions. Herbicides can directly affect non-target organisms (grey, green, blue), especially microbes (yellow), and cause ecosystem-level changes. Microbes are a significant component of all healthy living organisms. Thus, herbicides can indirectly affect the behavior and performance of organisms. These changes can further shape species interactions and ecosystems (ecological processes: blue arrows) as well as evolutionary processes (black arrows). This figure was created using BioRender (<https://biorender.com/>).

fungi impact their hosts' fitness [52], the selective suppression of fungal associates has the potential to shape plant communities and ecosystems based on them.

Likewise, plant rhizosphere bacterial communities are shaped by herbicide exposure ([50,53]; active ingredient and formulations). While the findings on gross community structures are variable and dependent on the plant host, the experimental system, and exposure levels, studies show a consistent reduction in the relative abundance of nitrogen-fixing bacteria ([54,55]; commercial formulations) and repression in plant-beneficial microbial functions (nitrogen fixation, 1-aminocyclopropane-1-carboxylic acid deaminase, and antifungal enzymes [53]; commercial formulations). As many plant traits, including growth, phenology, and resistance to abiotic stressors and pathogens, are modulated by rhizosphere microbiome, changes in rhizosphere composition and functioning are likely to be reflected in host fitness and growth [50].

In plants, the compounds derived from physiological pathways interfered with by herbicides, such as the shikimate pathway, are essential precursors for many plant defense and signaling metabolites. Therefore, sublethal doses of glyphosate (active ingredient and formulations) can potentially disrupt

Box 1. Active ingredients and co-formulants

Herbicides used in the field are a combination of the active ingredient and a complex mixture of co-formulants. A compound is classified as active when it is intentionally added for toxicity to target species. However, the active ingredient (e.g., glyphosate) of a herbicide is effective only if it can persist on the leaf surface long enough to penetrate the plant epidermis in variable weather conditions; thus, co-formulants are added to the commercial product to increase the efficiency of the active ingredient. Under the current regulations and laws, usually only the active ingredients are required to be tested for their toxicity to non-target organisms [11]. Furthermore, the co-formulants in a commercial product can vary geographically and over time and are regarded as confidential information.

An increasing number of studies is showing that the effects of commercial herbicide formulations on microbes and other non-target organisms are stronger than the effects of the active ingredient alone [8,12–14]. However, often it is not possible to differentiate whether the results are the outcome of the effect of the active ingredient, the co-formulants, or their combination, because many studies do not adequately explain what commercial formulations they have used. To better understand the ecological and evolutionary consequences of herbicides in natural ecosystems and agroecosystems, we need more well-replicated, field-realistic, and long-term experiments using active ingredients and various commercial formulants.

virtually all plant aboveground (**phyllosphere**) interactions with other coevolving organisms such as pathogens, plant-mutualistic microbes, herbivores, and pollinators [16,50,56,57] (Figure 1). For example, in *Arabidopsis thaliana* glyphosate altered the plant metabolome, causing a change in the core phyllosphere microbiome ([27]; active ingredient). Thus, microbial changes in the phyllosphere may be caused indirectly by changes in the plant metabolome, which may have a substantial impact on plant resilience and is likely to affect ecoevolutionary processes at the field scale [52]. Phytohormones are key regulators of plant metabolite biosynthesis in response to herbivory or microbial infections. Several plant-associated bacteria modulate plant phenotype by biosynthesis and the regulation of phytohormones such as auxins and ethylene [58]. Thus, residues of glyphosate-based herbicides in soil may disrupt the phytohormone homeostasis of plants directly or indirectly via altered microbiome [59]. On a field scale, the persistent effects of pesticides on the plant metabolome may have cascading effects in multitrophic and multispecies networks, with unknown consequences for entire ecosystems and the coevolution of plant–microbe and plant–insect dynamics [16].

Besides altering herbivory, herbicides can reduce pollinator visitation; both may be explained by changes in the volatile organic compounds (VOCs) released by plants [16,59] attracting pollinators and predatory insects. Some VOCs derived, for example, from the shikimate pathway are affected by low glyphosate doses ([60]; active ingredient). It remains to be elucidated to what extent glyphosate-mediated changes in the plant volatilome impact pollination or pest control, but global studies indicate general trends towards decreased ecosystem multifunctionality on agricultural fields managed using pesticides compared with organic farming [61].

Consequences of herbicides for animal hosts and species interactions

Both gut and skin microbiomes are known to influence animal health, playing key roles in digestion, pathogen resistance, and even neurobehavioral coordination in both invertebrates and vertebrates [5]. Herbicides with direct antimicrobial effects have been shown to influence microbiome composition in invertebrate and vertebrate hosts [3] (Table 1). So far, the studies in terrestrial invertebrates have mainly concentrated on bees (but see [62,63] for effects on beetles and mosquitoes using both active ingredients and formulations). For example, glyphosate (active ingredient) has been shown to increase pathogenic and decrease symbiotic bacteria [64,65], which may affect the susceptibility of bees to viral and fungal pathogens [56,66] with survival effects cascading to the ecosystem level. In addition to direct herbicide exposure, herbicide-altered plant microbiomes and/or metabolomes in plant leaves, pollen, and nectar may alter the exposure and consumption of pollinators and herbivores, which can have cascading effects on their gut microbiomes and, therefore, the health of the pollinators and herbivores [86]. Herbicides also lead to consistent compositional and functional changes in vertebrate models (mice and poultry [3,28,31,56,67]; both active ingredients

and formulations) with associated effects on, for example, endocrine and immune function [3,25]. Furthermore, herbicides proclaimed to lack antimicrobial function have been revealed to affect animal host gut microbiomes (e.g., in beetles, *Drosophila*, frogs, and mice [68–70]) (Table 1; both active ingredients and formulations). For example, low-dose paraquat (active ingredient) exposure remodeled the microbiome of *Drosophila Melanogaster*, simultaneously influencing the adult lifespan [70]. We propose that such effects of non-antimicrobial herbicides could be mediated via alterations of the host physiology, which then drives the changes in the microbiome.

Ultimately, herbicide-driven changes in animal-host gut microbiomes may lead to ecosystem-level changes. For example, altered gut microbiomes may directly affect pathogen resistance, endocrine disruption, and, therefore, the survival/reproduction of animals or cause changes indirectly by altering species–species interactions including pollination/herbivory, competition, or predation. These could result from altered behavior driven by modifications of gut microbiomes [71]. For example, altered gut microbiome and impaired locomotor activity and memory formation were reported in rats exposed prenatally to glufosinate ([31]; active ingredient). Understanding how these physiological and behavioral changes might contribute to organism performance is therefore a key future research challenge. To summarize, any herbicide-mediated change in host microbiome can have complex and unforeseen effects on species associations.

Evolutionary consequences for microbiomes and how they feed back to ecosystem level

In addition to the resistance of plants to herbicides, which can have cascading effects on ecoevolutionary dynamics [17], a widely known evolutionary consequence of repeated herbicide exposure is selection for increased herbicide resistance in free-living soil bacteria [19] (Box 2; see Figure 1 in Box 2). This can further feed back to the ecosystem level, as the resulting changes in the community composition may influence soil processes; for example, nitrogen and carbon flows [72]. Long-term exposure to herbicides may influence not only microbial evolution but also the evolution of the animal hosts driven via microbes. For example, atrazine (active ingredient) exposure for 85 generations in the wasp *Nasonia vitripennis* led to adaptive changes in the gut and exerted selective pressure on the host genome [68]. These results indicate that herbicide-mediated host–microbiome coadaptation is leading to a new host-genome–microbiome equilibrium. The effects of herbicides on animal-host gut microbiomes can also feed back into soil processes when they influence soil fauna, such as earthworms, contributing to detoxification [73], decomposition, and nutrient cycling [74]. Several herbicides have been found to decrease earthworm microbiome gut diversity ([75,76]; active ingredient and formulations), which may lead to both impaired soil processes and selection on hosts.

What limits current understanding of ecosystem-level effects?

The lack of published studies limits our understanding of the extent and complexity of the ecosystem and the evolutionary effects of herbicides. First, the co-formulants in herbicides can have additive or synergistic effects that complicate the predicted effects of active ingredients (Box 1) but have not been thoroughly quantified. Second, most studies are conducted in the laboratory or on agriculturally important/model species, which poses several constraints. Model systems in the laboratory fail to capture the breadth of variability inherent in wild coevolving microbes, plants, and animals, their interactions, and their responses to variable environments. Thus, the ecoevolutionary consequences on ecosystems are impossible to quantify in the laboratory. Although mechanisms can be examined in laboratory studies, the dosages and durations of herbicide exposure are challenging to adjust equivalent to the exposure in the natural environment. This holds true, especially, in long-term studies with low chronic exposure levels. Although knowledge on the complex and indirect effects of

Box 2. Evolution of resistance to glyphosate

Some species have evolved a variety of mechanisms resistant to glyphosate, including target-site and non-target-site mechanisms [77] (Figure I). Target site susceptibility can be determined based on bioinformatic analyses of amino acid markers in the target protein sequence. The evolution of target site sensitivity to glyphosate has been thoroughly studied through the identification of amino acid markers in the EPSPS active site [18]. Although the phylogenetics and lifestyles of bacteria may determine the potential sensitivity to the glyphosate, the status may easily change by single mutations in the EPSPS active site or via horizontal gene transfer [19]. Moreover, glyphosate may affect additional metabolic pathways, such as the mitochondrial electron transport chain [78–80]; thus, some species may be sensitive to the herbicide even in the presence of the EPSPS-resistant copy of the protein. The exposure hypothesis (i.e., free-living bacteria that are more exposed tend to be more resistant to the herbicides than host-associated and parasitic bacteria) has been suggested for glyphosate based on the analysis of target site mechanisms [19]. However, literature-mining studies suggest that pathogenic bacteria are likely to be more resistant to the herbicide than free-living and host-associated bacteria [3,81], which may be explained by their greater genomic plasticity [82]. Moreover, there are differences in target site sensitivity to glyphosate among animal organs and plant tissues [81]. Further empirical studies are needed to disentangle the association between target and non-target site mechanisms as well as the role of glyphosate and other herbicides in the selection for antimicrobial-resistant bacteria [83–85].

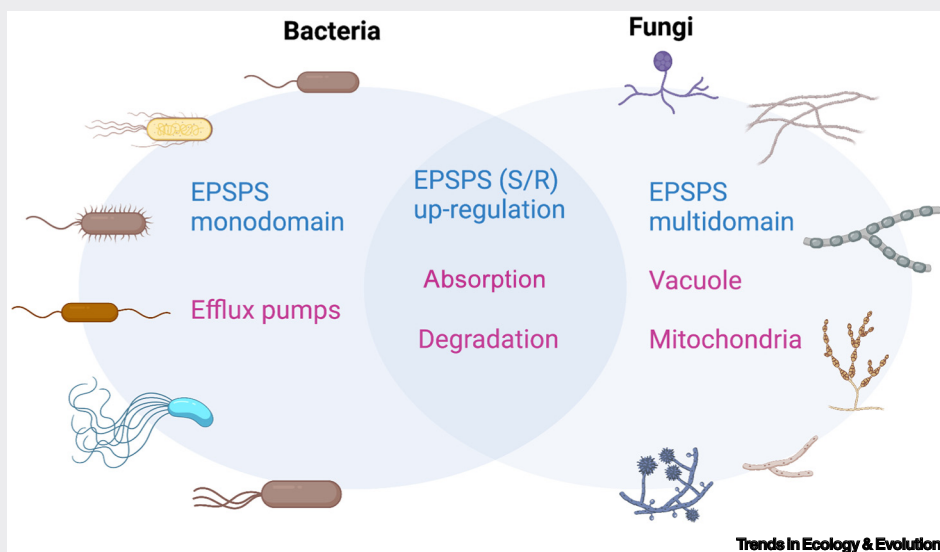


Figure I. Target-site (blue) and non-target-site (purple) mechanisms of sensitivity/resistance (S/R) to glyphosate. This figure was created using BioRender (<https://biorender.com/>). Abbreviation: EPSPS, 5-enolpyruvylshikimate-3-phosphate synthase.

herbicides on microbes is emerging, the empirical studies on the wider ecoevolutionary consequences of the long-term use of herbicides remain lacking.

Concluding remarks

The health of microbial communities is extremely important, since they maintain the well-being of ecosystems. By altering microbial communities, herbicides can have far-reaching, long-term, and unforeseen impacts on ecosystems. Therefore, tackling the threats caused by agrochemicals requires tools and solutions based on a comprehensive understanding of microbe-mediated risks (see [Outstanding questions](#)). To truly address and control microbiome-mediated herbicide effects, these must be considered in future assessments of the registration of pesticides that currently do not involve microorganisms.

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Outstanding questions

What are the effects of co-formulants in commercial products on microbes and microbial communities?

How do herbicide residues affect soil ecosystem functions, such as nutrient cycling, via changes in microbiomes?

How do herbicide effects on direct and indirect (microbiome mediated) pathways influence species interactions in wild and agricultural ecosystems?

What are the effects of herbicide-modulated microbiomes on ecosystem functions and services?

What are the evolutionary consequences of herbicide-altered changes in ecosystem functions?

Declaration of interests

The authors declare no interests.

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Subject: To SPPDAC Committee: Surface and Groundwater Usage Questions



Jetty Creek July 2024 Measurement under .7

Rockaway Beach Source Water Protection Plan Risk Prioritization Table.

To make good decisions regarding protecting *all* the drinking water used in Rockaway Beach (both surface water from Jetty Creek *and* groundwater from the Nedonna wells), we need to know what is the monthly streamflow in Jetty Creek. Broken down by month, how much of the water used comes from Jetty Creek and how much comes from the wells? How have these numbers changed in the

last twenty years? My understanding is that the wells are used when Jetty Creek is experiencing heavy turbidity and in the summer months when the creek water flow is low. Before the water is treated, what are the measured levels of turbidity? How much chlorine is being used to treat the raw water?

On Saturday, July 27, I took a look at the Jetty Creek stream monitor that's on the southwest side of the treatment plant, and it measured slightly below 0.70. How is the monitor calibrated? How much water flow does 0.70 represent? The water level looked very low. Is there enough water there for the coho salmon which are "listed?" In Aug. 2023 the same monitor read .6 (please see attachment "Coastal Water Crises.") Presently, at the end of July, are we using the wells and, if so, how much? Please see the attachment that shows incomplete RB water usage tables.

The entire Nedonna Beach neighborhood is in the DEQ-defined source water protection area for Rockaway Beach's groundwater (the Nedonna wells). Nedonna Beach already has about 370 houses in this area at high risk from tsunamis, earthquakes, floods, king tides, rising sea levels, extreme weather, and wildfires. Seventy-five percent of these homes use septic systems and the remainder are on the RB sewer system. These septic systems, many of them aging, are poorly regulated and inspected. The Nedonna wells are shallow (only about 50 feet below the surface) and, thus, are not far below the septic systems. More stress may be put on these wells by additional home construction and fluids from vehicles using the roads; pesticides, fertilizers, and chemicals from personal care products; and storm water overflow. These wells are in close proximity to the ocean; so, they are naturally subject to salt water infiltration.

If more houses are built in a high-density PUD (planned unit development) proposed to be built in close proximity to McMillan Creek, more stress will be placed on these wells, further degrading them. McMillan Creek, and the surrounding area, is home to beaver, fish, and other wildlife. It flows into the Nedonna Marsh estuary, a saltwater and tidal water area that flows into Nehalem Bay and the ocean. Jetty Creek also flows into this estuary which is designated as salmon migration and nursery waters.

In 2008, approximately twenty percent of the Jetty Creek watershed had been clearcut and sprayed with pesticides. Sixteen years later, approximately ninety percent of that watershed has been clearcut and sprayed numerous times with pesticides. This has seriously compromised drinking water quantity and quality. Now because of these industrial forestry practices, we have lower stream flows in the summer, resulting in less drinking water available. It should be noted that Rockaway Beach does have water rights to McMillan Creek; therefore, everything should be done to protect it.

In summary, we do need to protect the Jetty Creek watershed, but we also need to protect our groundwater source area (the Nedonna wells) that face many stressors. These stressors seriously threaten our water quality and quantity.

Submitted by Nancy Webster
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A Coastal Water Crisis in Jetty Creek and Beyond

