Reviewer #2

In "Ecosystem leaf area, gross primary productions, and evapotranspiration responses to wildfire in the Columbia River Basin" the paper compares metrics of resistance and resilience of the MODIS-derived products mentioned in title across 3 primary vegetation types that underwent different burn severities from 138 fires in 2015. Resistance is calculated as the ratio of the 2016 annual maximum value for LAI, GPP, and ET to the average annual max value from the 4 years preceding the fire (2011-2014). Resilience is ratio of the average annual max values of LAI, ET, and GPP during 4 post-fire years (2017-2020) to the average annual max values during the 4 pre-fire years. A random forest approach is used to compare the influence of precipitation, vapor pressure deficit and burn severity on resilience of the three vegetation types (needleleaf evergreen forest, woody savanna, and grasslands). The paper concludes that 1. increased burn severity decreases resistance and resilience of LAI, GPP, and ET across all vegetation types, 2. LAI resistance and resilience is the most impacted by burn severity, 3. grassland LAI, GPP and ET are more resilient and resistant to wildfire than that of evergreen forests and savannas, and 4. burn severity is the primary driver of resilience in evergreen forests and savannas, while VPD and precipitation determine grassland resilience.

This paper's methods and results are thought provoking and likely of interest to many. In addition to sharing concerns regarding the uncertainty issues addressed by the first reviewer, I have identified other limitations that should be addressed. Namely, the resistance and resilience metrics in this study are produced using different data than in the key cited paper (DeSoto et al., 2020) and thus there must be clear differences in the interpretation of the results.

The short post-fire study period undermines discussion related to resilience. This paper claims that low resilience values relate to low chances of full recovery (438-439). However, a 4-year post-fire study period is too short to assess the likelihood of recovery when forest recovery can take decades. If the authors decided to retain this resilience metric, the interpretation needs to appropriately acknowledge and match the limitations of the method.
Reply: This sentence is updated as "*This study implies that with these changes, some ecosystems may need a long time frame to achieve full recovery. This prolonged recovery could keep carbon stocks at relatively low levels for decades to a century (Turner et al., 2019) and affect the ecosystem function and ecosystem–atmosphere interactions (Harris et al., 2016).*"

Additionally, the authors do not use DeSoto's ecosystem recovery metric. At the very least, there should be discussion of why that is not used since they otherwise rely on DeSoto's framework. DeSoto et al. 2020 define recovery as the ratio between the post disturbance value and the value during the disturbance, and thus resilience (post disturbance/pre disturbance) is a product of both resistance (disturbance/pre disturbance) and recovery (post disturbance/ disturbance). Based on figure 2, recovery of LAI, GPP, and ET appear quite similar across the three vegetation types following severe burn. Thus, observed differences in resilience are driven primarily by differences in resistance as opposed to recovery. I believe that it is key that this paper properly discuss the nuanced differences in interpreting recovery (seemingly similar across these ecosystems) and resilience and resistance (seemingly contrasting).

Reply: To simplify our analysis, we use resistance and resilience to represent disturbance intensity (i.e., disturbance/pre-disturbance) and the capacity of a system to recover (i.e., post-disturbance/pre-disturbance), respectively. The equations of these two metrics are following Eqs. (1) and (3) in DeSoto et al. (2020). Essentially, the product of resistance (disturbance/pre-disturbance) and recovery (post-disturbance/disturbance) cancels out the "disturbance" term—defined as the value during disturbance. Figure 2 (now Figure 1) focuses solely on resistance (i.e., values in 2016) and resilience (values in 2017 and after).

The reviewer commented that "*Thus, observed differences in resilience are driven primarily by differences in resistance as opposed to recovery*". However, based on Eq (2) in this paper or Eq (3) in DeSoto et al. (2020),

$$\text{Resilience} = \frac{\bar{A}_{2017-2020}}{\bar{A}_{2011-2014}}$$

The status in 2017 and after could be closely related to the status in 2016 (i.e., the value during disturbance), and compared to resistance, the resilience values are determined by the post-disturbance values, implying the ecosystems' capacity to recover. On the other hand, "recovery" is represented as DeSoto et al. (2020):

$$\text{Recovery} = \frac{\bar{A}_{2017-2020}}{A_{2016}}$$

Based on Eqs. (1)–(3), the only difference between "resilience" and "recovery", as defined by DeSoto et al. (2020). is whether the pre-disturbance value or the value during disturbance is used as the denominator for the calculation. These three variables, resistance, resilience, and recovery, are not one determine another, but use different time frames, pre-disturbance—disturbance— post-disturbance, to characterize the system's responses to disturbance with different intensity. We also added the following description in Section 2.5:

"*DeSoto et al. (2020) define recovery as the condition following a disturbance compared to the condition in the year when the disturbance occurred, which can be represented by the following equation:*

$$Recovery = \frac{\bar{A}_{2017-2020}}{A_{2016}} \qquad (3)$$

Thus, the primary distinction between resilience and recovery lies in the reference conditions: pre-fire versus the disturbed conditions. Resilience is defined as the capacity of a system to recover its structure and function after a disturbance (Holling, 1973). To ensure clarity in our discussions of recovery status, we use the term resilience throughout this study."

Additional Major Comments:

Burn severities are presented as a key driving factor but I could not find information (in either the article or SI) about the distribution of burn severities across the different primary vegetation types. This would provide useful context for figures 3 and 5. Also, there is no discussion concerning the issues with burn severity classifications in grasslands compared to forests. Are there differences in classifications between vegetation types that readers should consider? Do MTBS algorithms and workflows perform similarly well in grasslands, savannas and forests?

Reply: Figures S1 provides detailed information of VTs and Figure S2c provides burn severity levels over the CRB. In addition, we add Figure S2d to further show the VTs in all the Figure S2c indicated fire scars. Typically, northern CRB is more prone to forest fires, whereas southern CRB is primarily affected by grassland fires. We also provide the fire types across different VTs (Figure S2b). We also add the description in the first paragraph of Section 3.1 as:

"*Generally, northern CRB experiences a higher incidence of forest fires, whereas southern CRB is mainly affected by grassland fires (Figures S1, S2c, and S2c).*"

The MTBS mapping is primarily based on the differenced normalized burn ratio (dNBR) algorithm and the LandSat imagery at the near-infrared and SWIR bands (Eidenshink et al., 2007). The same dNBR algorithm is applied to all vegetation types, and differenced NBR images (i.e., post-fire NBR subtracted from pre-fire NBR) are referred to as dNBR images. The differenced pre-fire and post-fire NBR images result in a fire-related change image that is classified into severity classes and provides an unbiased basis for analyzing additional fire effects. Thus, a same burn severity value in both a forest and a grassland system implies these two systems have the same range of changes (i.e., variations) in terms of NBR. The clarification is also added the following sentence in the second paragraph of Section 2.2:

"*The MTBS mapping primarily relies on the differenced normalized burn ratio (dNBR) algorithm and LandSat imagery in the near-infrared and SWIR bands (Eidenshink et al., 2007). The same dNBR algorithm is applied across all VTs. Differenced NBR images—where post-fire NBR is subtracted from pre-fire NBR—are known as dNBR images. These dNBR images illustrate fire-related changes, which are categorized into severity classes, providing an unbiased foundation for analyzing additional fire effects.*"

Vegetation classifications are based on a 2015 MODIS dataset. For those areas that burned in 2015, do more recent land cover type datasets suggest a possible change in vegetation cover type? The authors do not discuss possible land cover conversion following different severity burns. Indeed, in figure 3 savannas seem to respond like grasslands at high severities and forests at low severities. While the post-fire study period is not long enough to expect full forest or savanna recovery from severe burn, more explicit discussion on conversion is warranted.

Reply: We compared the vegetation types (VTs) in 2014 (pre-fire) and 2020 (the fifth year after fire), and applied the burn severity map (with fire boundaries; Figure S2c) to the VT difference map to show the fire scars with VT changes. That is the data pixels without fire but with VT changes are excluded from this evaluation. This new comparison is included in Figure 5 and Discussed in Section 4.1. The results showed that there were 67090 data pixels in the Columbia River basin experienced the 2015 fires. Even though there are many grassland fire events (Figure S2b), 13363 (20%) needleleaf forest, 7832 (12%) woody savanna, and 706 (1%) grassland pixels experienced VT changes among all the fire disturbed pixels (Figure 5). Thus, the 2015 wildfires induced the degradation of VTs with woody components. As we discussed in the paper that grasslands are better adapted to wildfire (e.g., Isbell et al., 2015), this analysis further confirmed the results of previous studies. We added the discussion in the last paragraph of Section 4.1 to further explain the resilience value variations between VTs.

Technical corrections:

61-62: change to: "greater reductions in ET to precipitation ratios (ET/P)"
Reply: Updated.

63: Is "respectively" needed?
Reply: "respectively" is deleted.

63-66: Please improve the wording of this sentence.
Reply: This sentence is updated as "*Through the use of the Moderate-resolution Imaging Spectroradiometer (MODIS) GPP product, a Hurricane Rita based study suggests the difference in GPP recovery rates and resilience index between different vegetation types (Frazier et al., 2013).*"

70: Start sentence with "There".
Reply: Updated.

83-85: Rearrange this sentence, possibly split into two sentences.
Reply: This sentence is updated as "*Furthermore, the influence of environmental factors on post-fire ecosystem recovery, as characterized by LAI, GPP, and ET, remains inadequately quantified. This lack of clarity is closely linked to the uncertainties in predictions made by Earth system models (ESMs; Lawrence et al., 2016).*"

93: Replace ", experienced" with "across"
Reply: Updated.

95 -105: It would be easier to read if the hypotheses were simply listed. The discussion of concerning results from previous studies may be better earlier in the introduction or later in the discussion section.
Reply: The hypotheses are directly listed, and the fifth paragraph in the Introduction and the first paragraph in Section 4.3 are reorganized.

108-113: The final part of the sentence about increasing wildfire severity in the CRB should be another sentence.
Reply: The final part is updated as "*Given that the impacts of wildfires are expected to intensify in CRB (Halofsky et al., 2020; Wimberly et al., 2014) and globally (Andela et al., 2017; Bowman et al., 2020., Jones et al., 2024), quantifying fire impacts is essential for both ecosystems and society. The research framework of this study can be broadly applied to quantify wildfire-induced ecosystem responses and evaluate the impacts of wildfires as revealed by different data products and represented by ESMs.*"

361: Including "(e.g., grasses)" is misleading. DeSoto et al. 2020 compares gymnosperm and angiosperm *tree* species, there is no discussion about grassland recovery.
Reply: This sentence was deleted.

116: Unnecessary first sentence.
Reply: Deleted

130: include "annual 500 m" before "MODIS" and delete the second sentence.
Reply: Updated.

132-135: Combine these two sentences.
Reply: This two sentences are updated as "*The VT map in 2015 shows that needleleaf evergreen forest (NEF), woody savannas (WDS), and grassland (GL), and croplands are the four dominant vegetation cover types over the CRB (Figure S1), and we study the impacts of wildfire over the NEF, WDS, and GL VTs.* "

153: Replace "burnt" with "burn"
Reply: Updated.

153-156: Start a new sentence after "respectively".
Reply: This part is updated as "*MTBS employs different integers to indicate burn severity categories, with values ranging from 1 to 4 representing unburned, low, moderate, and high severity, respectively. Consequently, the upscaling processes using the area-average remapping method produce floating-point numbers.*"

158: Delete "in 2015".
Reply: "in 2015" is deleted.

168: Replace "water" with "vapor".
Reply: Updated.

171: Replace "data sets" with "datasets".
Reply: Updated.

192-194: Strange wording and see reviewer 1's comment.
Reply: This part is clarified by adding descriptions in the end of Section 2.2.

Table 1: Agree with reviewer 1: move to SI. Also it's VPD, not WPD.
Reply: Table 1 is moved to SI with the data usage time frame and "VPD" updated.

209: Delete the extra period.
Reply: Deleted.

230: Capitalize Python.
Reply: Updated.

252-254: This should be in the methods section.
Reply: This part was updated by following the suggestions of both Reviewer #1 and Reviewer #2.

Figure 1: Agree with reviewer 1: better in the SI.
Reply: Figure 1 is moved to SI.

310-312: Strange wording.
Reply: This sentence is updated as "*In NEF, precipitation and VPD have importance scores of 0.3 for LAI resilience, while that of burn severity is 0.4 (Figure 4a).*"

316-317: First half of the sentence is poorly worded.
Reply: This sentence is updated as "*The importance scores for GPP and ET represented resilience show variations. However, the overall conclusion regarding the contributions of these three metrics to resilience values remains consistent across the VTs.*"

356: Replace "till 2020" with "within the post-fire study period".
Reply: Updated.

364: Delete the "y" on "fully".
Reply: Updated.

376: Delete "the result reveals".
Reply: "the result reveals that" is deleted.

378: Replace "the findings" with "previous work showing".
Reply: The first half of this sentence is updated as "*The results are consistent with the previous studies showing that forests tend to increase stomatal conductance and hydraulic efficiency, …*"

395: Delete this first sentence.
Reply: To update the fifth paragraph of Introduction, we move the discussion of a previous study in Section 4.3. This sentence is updated correspondingly. Please check the first three sentences in Section 4.3 for the details.

396: "Though, burn severity is less important to grassland resilience,"
Reply: Updated

399: Use "interaction".
Reply: Updated.

407: Delete “across”.
Reply: Deleted.

438-439: How does this study imply that these ecosystems may have extremely low chances of full recovery? 4 years is not a very long post-year period.
Reply: This sentence is updated as “*This study implies that with these changes, some ecosystems may need a long time frame to achieve full recovery. This prolonged recovery could keep carbon stocks at relatively low levels for decades to a century (Turner et al., 2019) and affect the ecosystem function and ecosystem–atmosphere interactions (Harris et al., 2016).*”