Determining the impact of oil spills on vegetation in the Niger Delta using satellite imagery

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Presentation outline

Introduction

Study area

Data

Methodology

Results & Discussion

Conclusions

Introduction

- Land cover in the Niger Delta Region has been significantly affected by oil extraction activities, especially the vegetation

- Monitoring the health of vegetation exposed to oil spills in environs such as the Niger Delta can be challenging

- In this research we aim to investigate the following using Earth Observation data:
  - the role of volume of oil spills and time gap after spills on the ability to detect the effects of oil spills on vegetation health
  - the temporal response of vegetation following exposure to oil spills

Study Area

- The Niger Delta is located in the Central part of Southern Nigeria
- It is the most densely populated river delta worldwide and has the third largest mangrove forest in the world
- Estimated hydrocarbon reserves of nearly 40 billion barrels (bbl)
- Comprising ~70% of the overall hydrocarbon reserves of sub- Saharan Africa

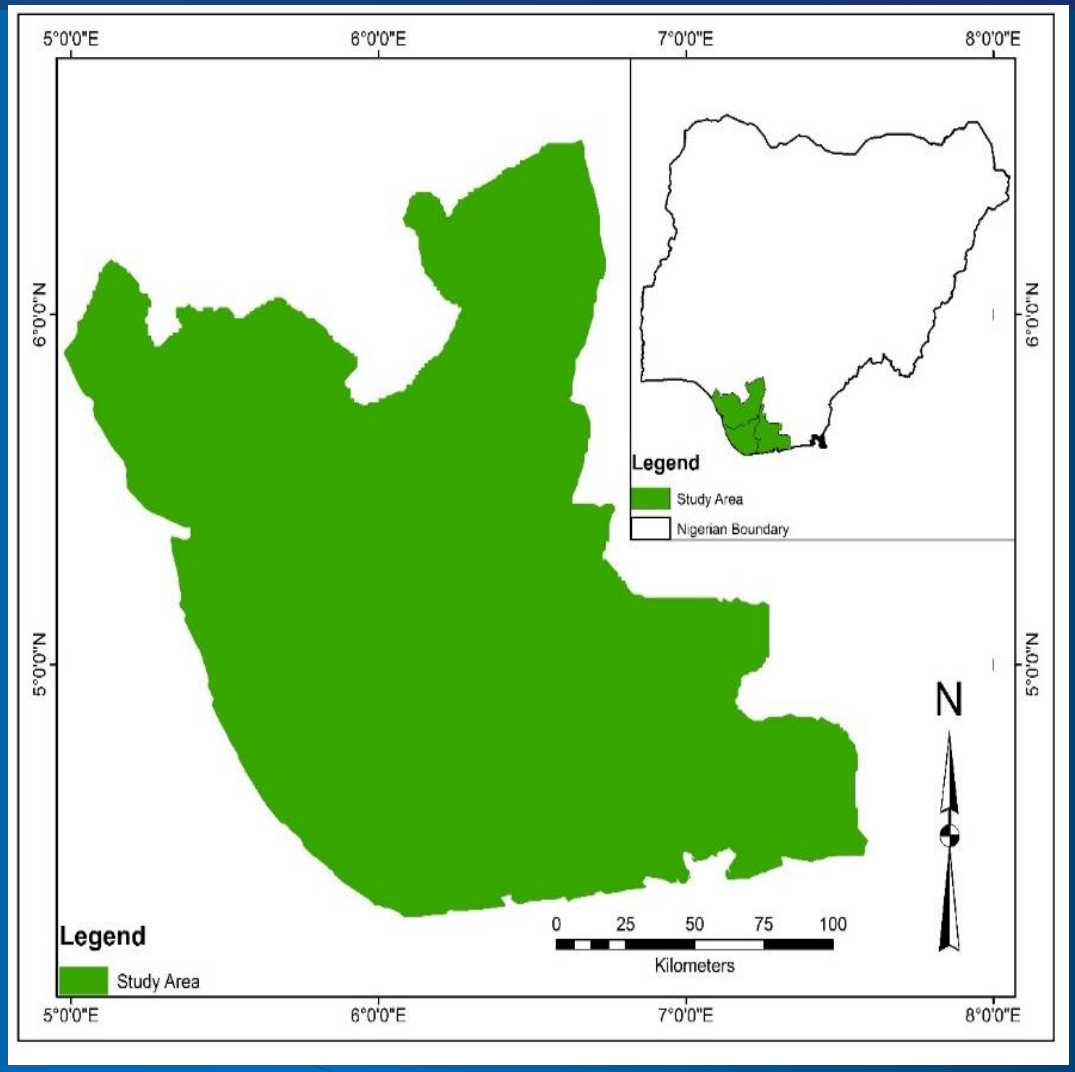

Figure 1: Map of Nigeria, Niger Delta in light blue and the study area in red.

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Some oil spills sites

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Data

Table 1: Landsat image downloaded from the USGS website and geometrically corrected and projected to WGS 84 Universal Traverse Mercator Projection Zone 31 and 32.

Satellite	Sensor	Path/Row	Years of images acquisition	UTM Zone	Pixel sizes(m)
L7	ETM+	188/56	2006 to 2018	32	30
L7	ETM+	188/57		32	30
L7	ETM+	189/56		32	30
L7	ETM+	189/57		31	30
L7	ETM+	190/56		31	30

Oil spill data:

- The oil spill data were downloaded from Nigerian Oil Spill Monitor website https://oilspillmonitor.ng

- The data is collected by the National oil Spill Detection and Response Agency (NOSDRA) and it contains spatial and attribute data

Methodology

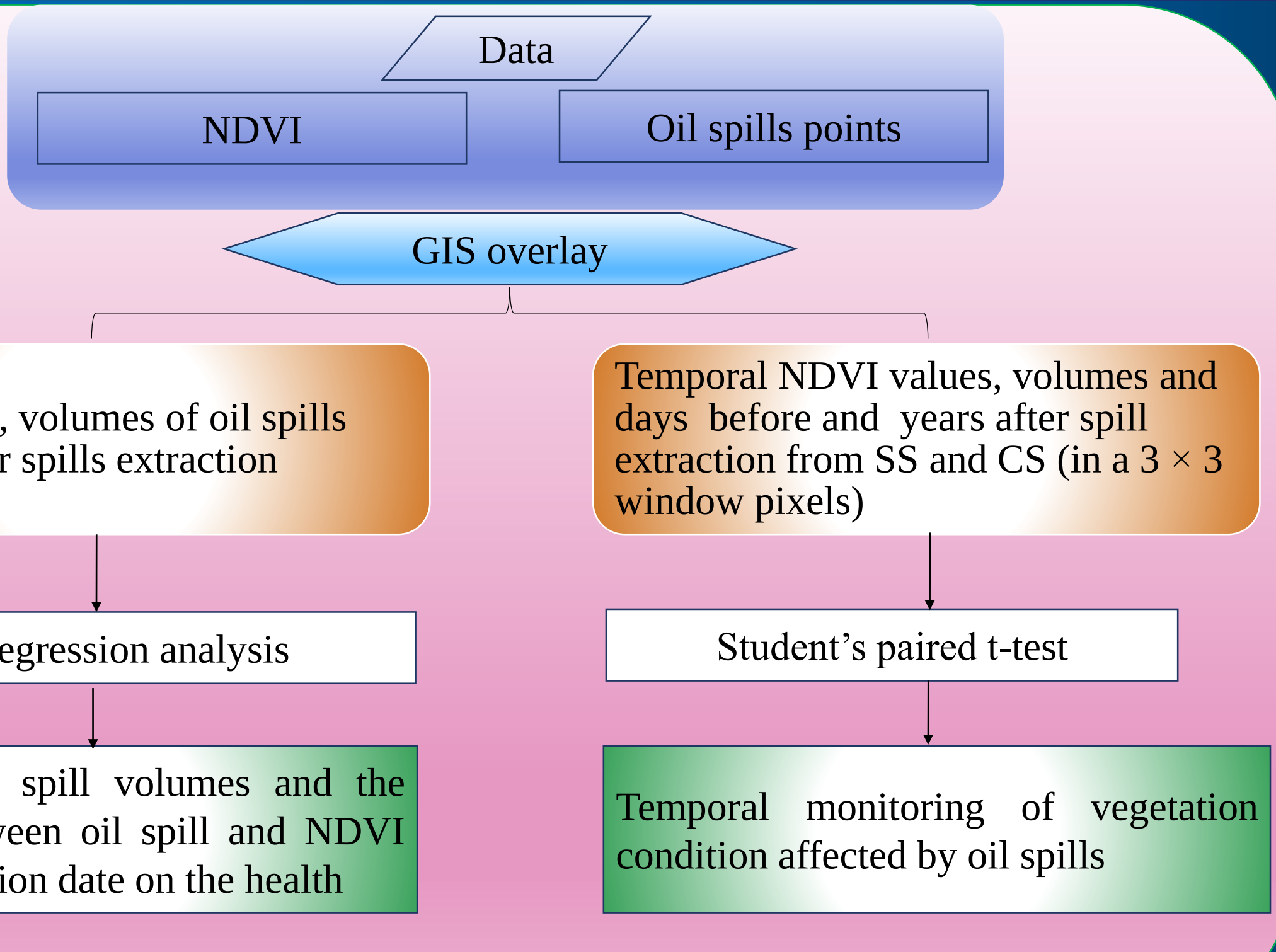
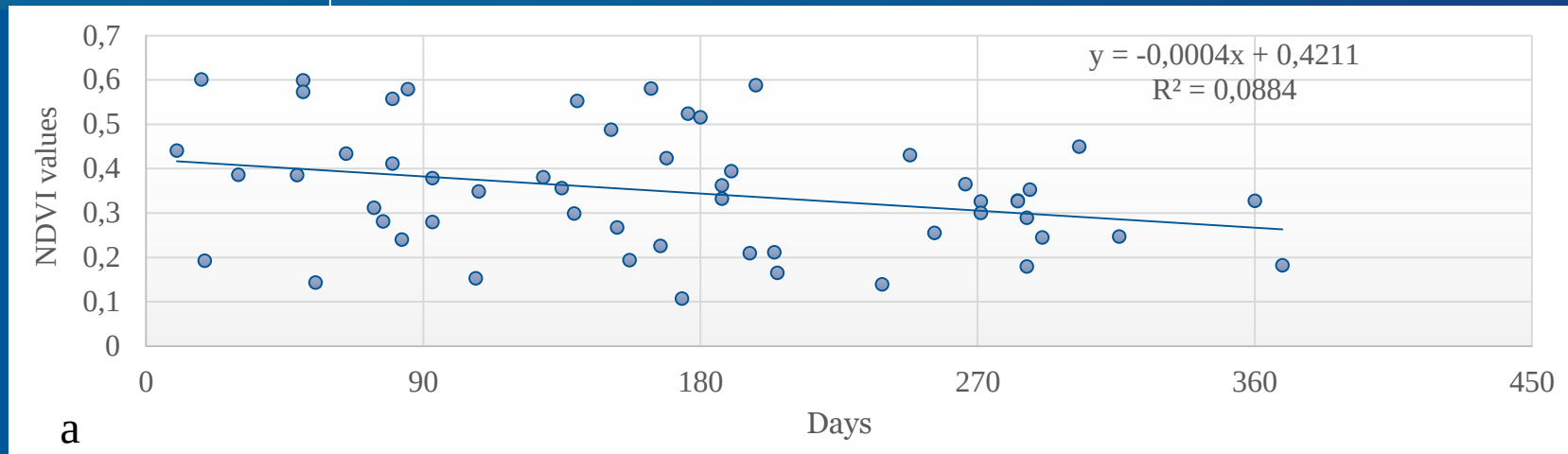
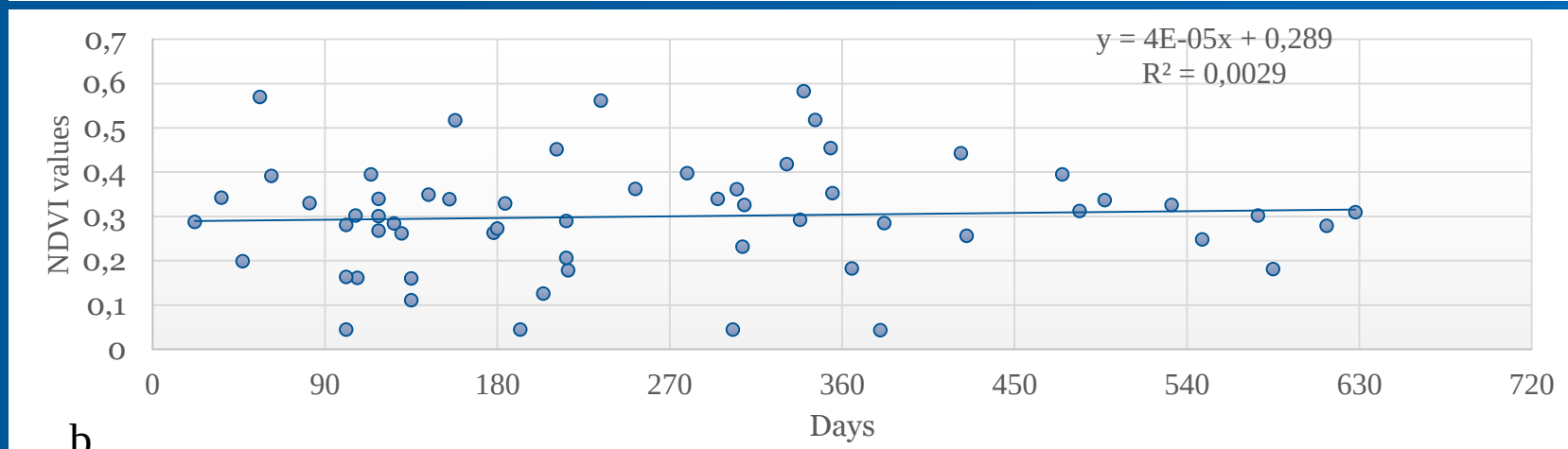
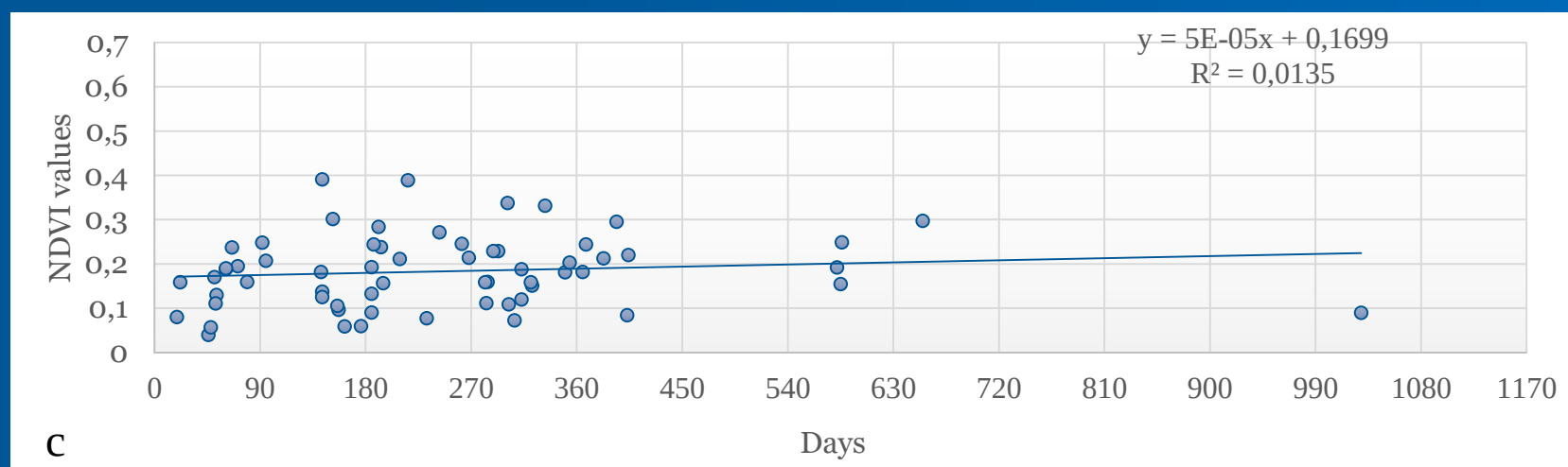


Figure 2: Methodology Flow Chart.

Results & Discussions: impact of oil spill volume and time gap on the health of vegetation







- It takes longer time for DV to respond to the impact of oil spills

Figure 3: The relationship between NDVI and time gap after oil spill for (a) Dense vegetation (DV), (b) Sparse vegetation (SV) and (c) Mangrove vegetation (MV).

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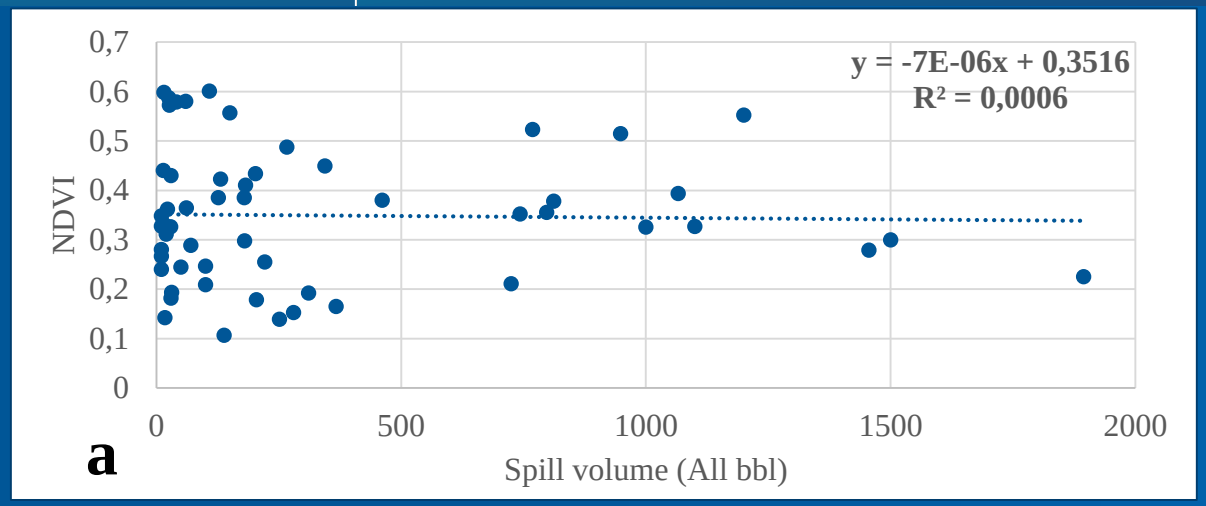
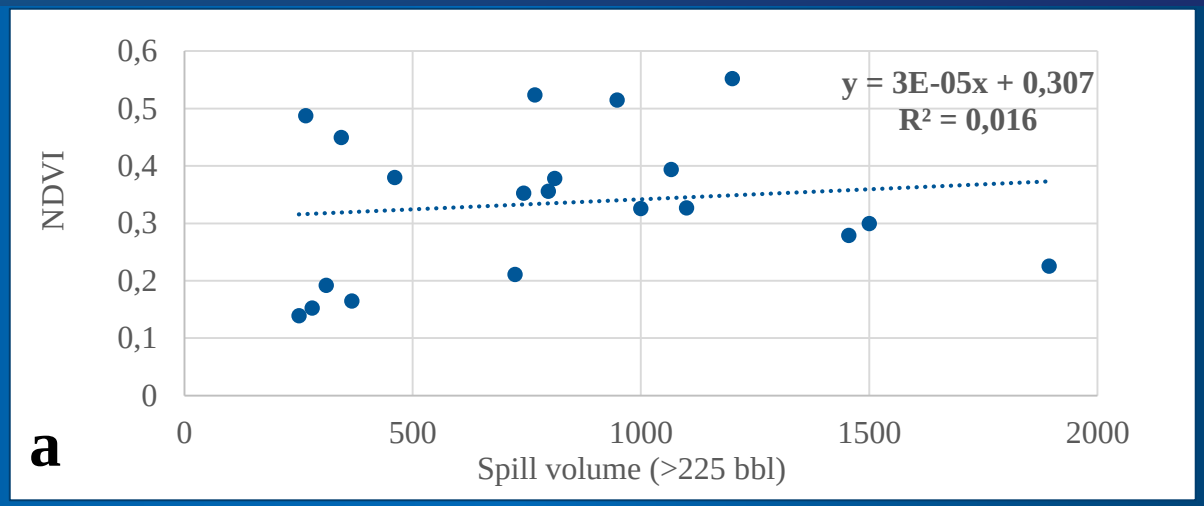
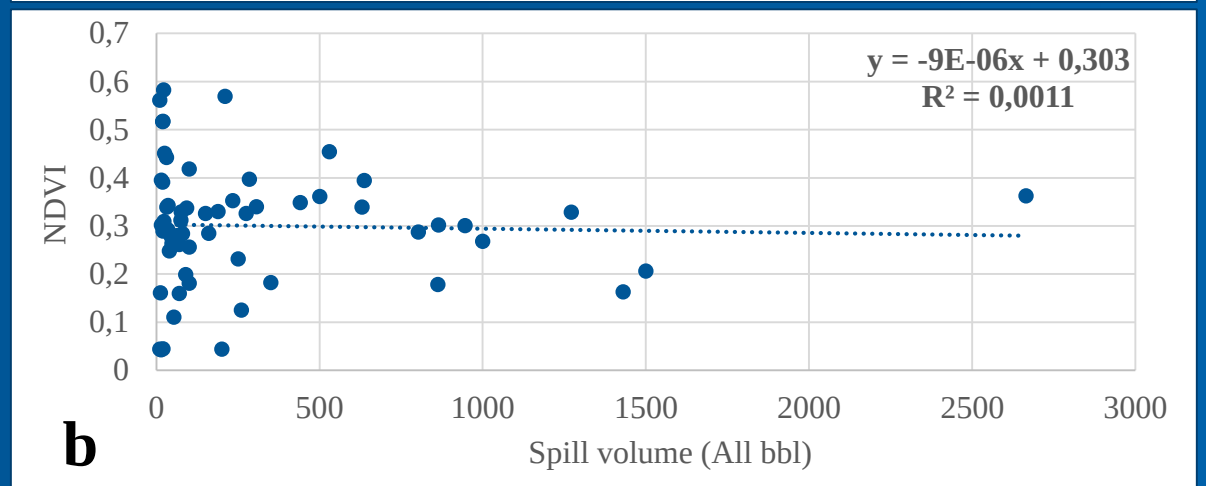
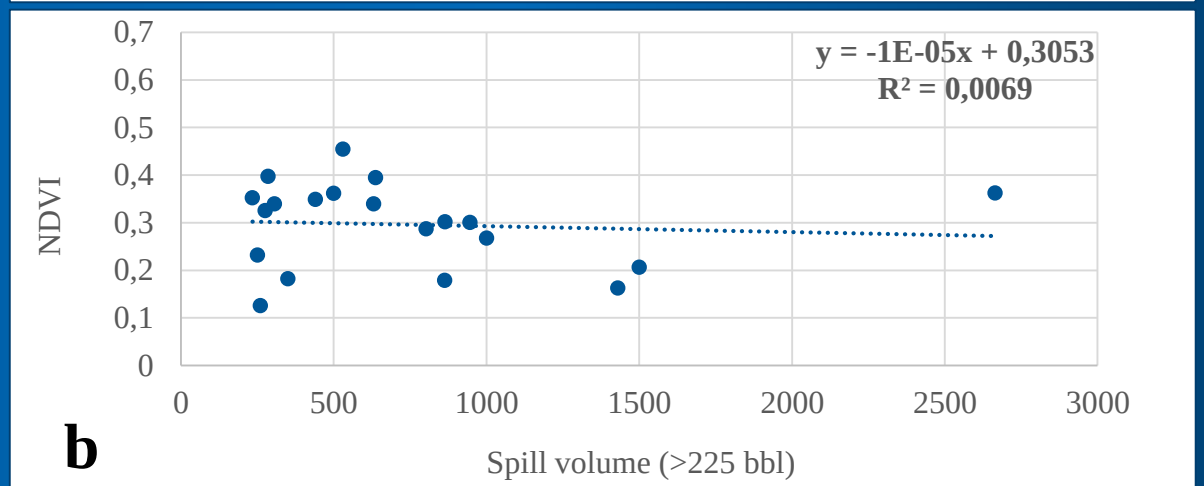
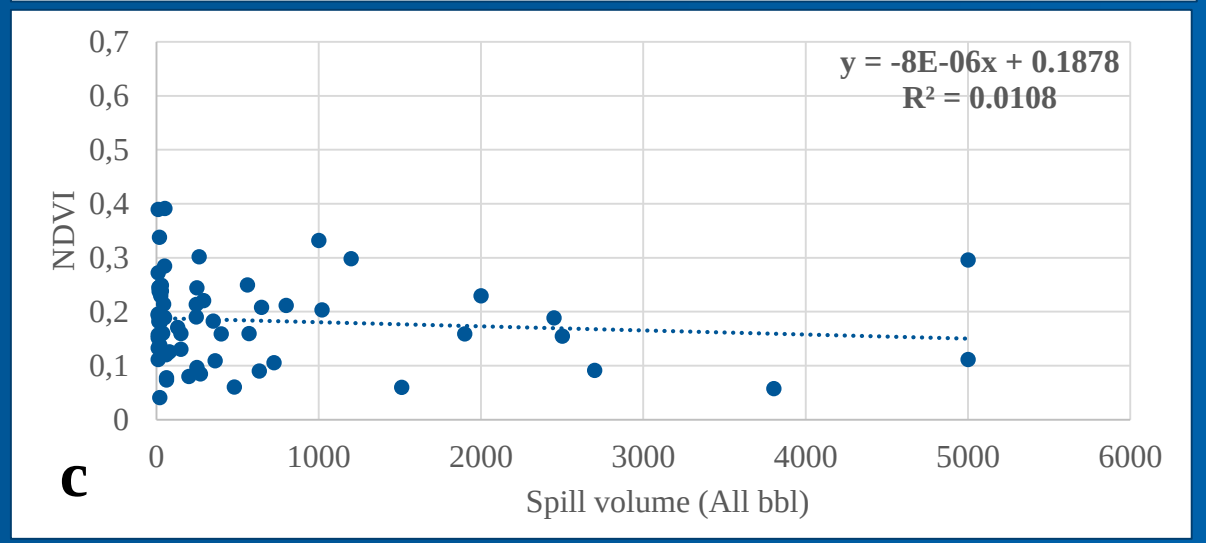
Impact of oil spill volume on the health of vegetation











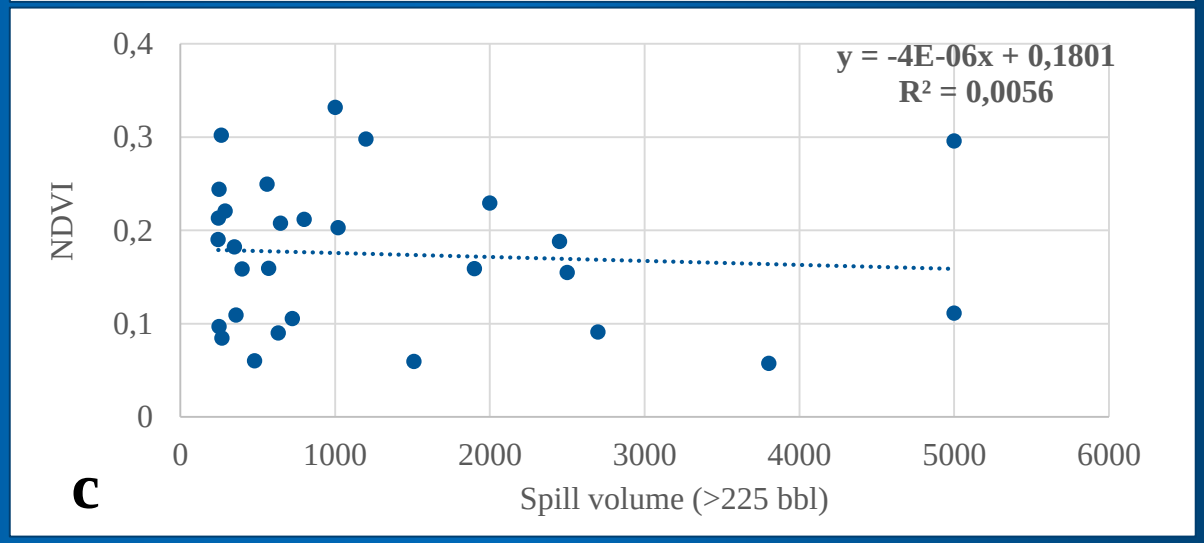
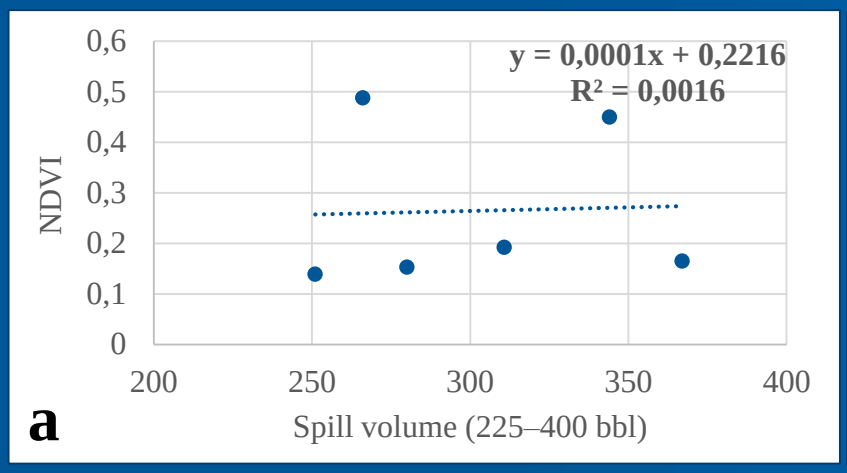
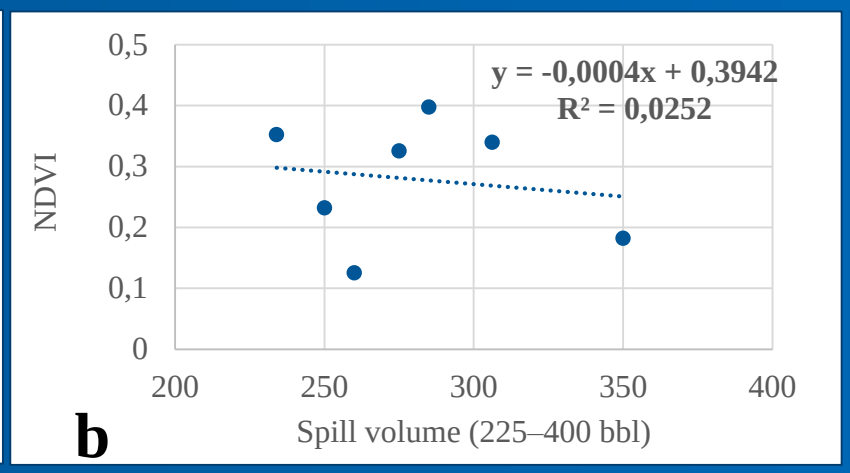
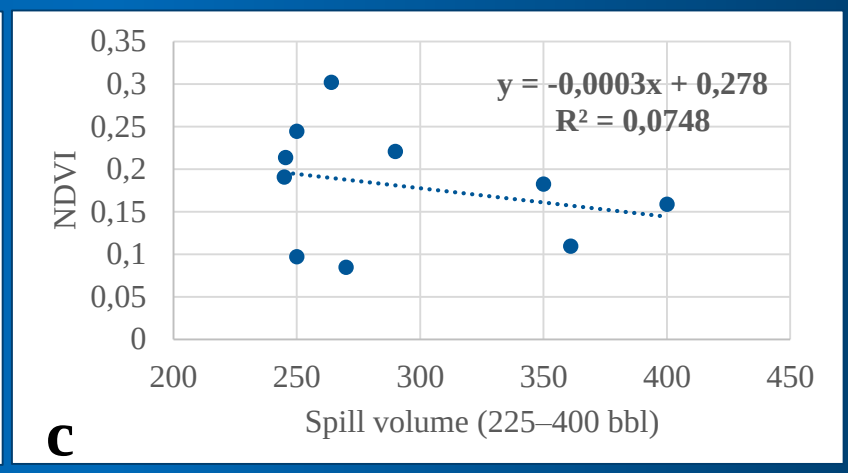


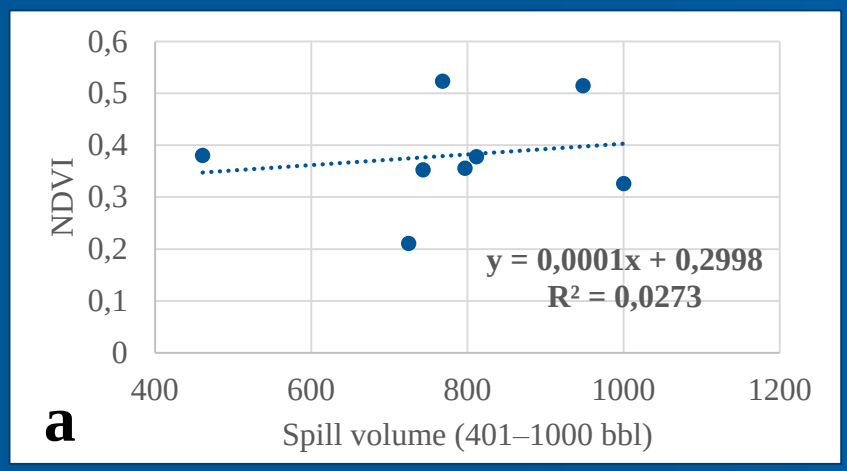
Figure 4: The relationship between NDVI and oil spill volumes (all volumes in column 1; >225 bbl in column 2) for (a) DV, (b) SV and (c) MV.

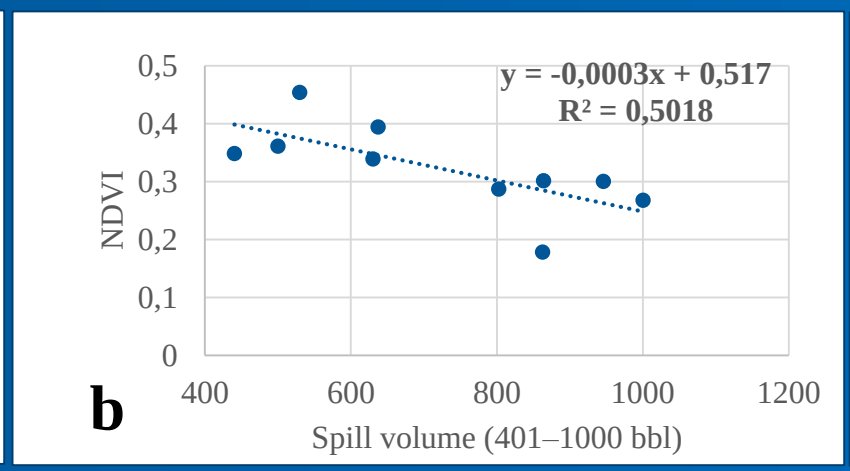
Impact of oil spill volume on the health of vegetation…cont.

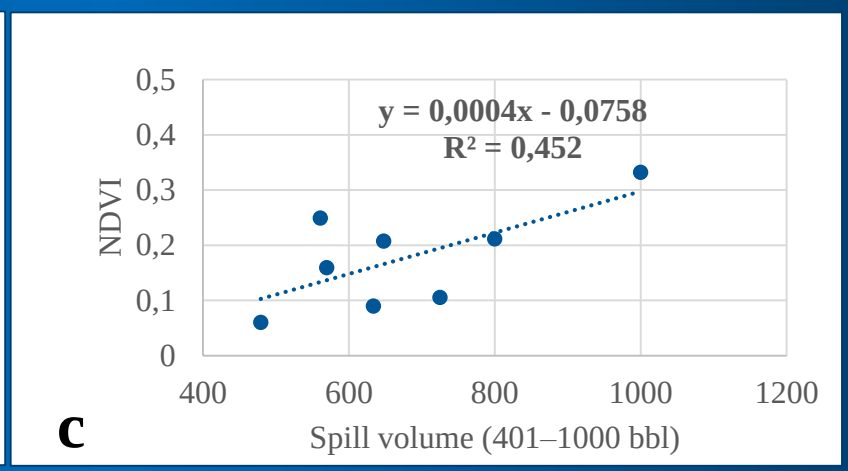


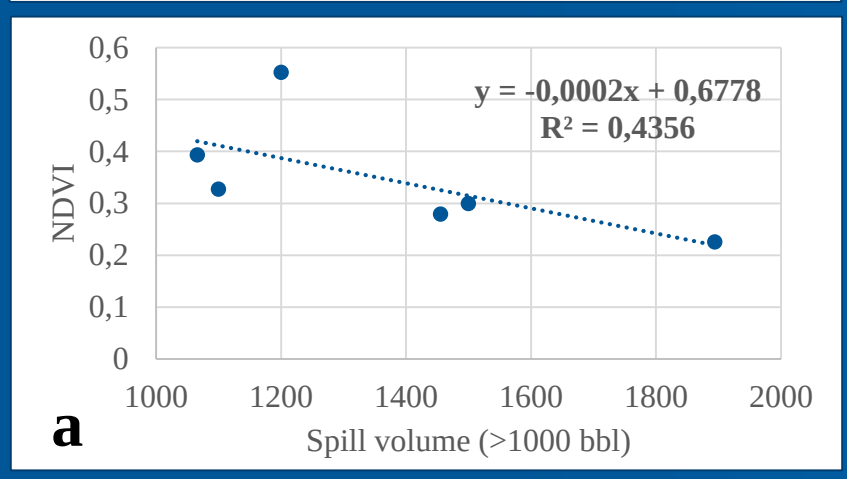


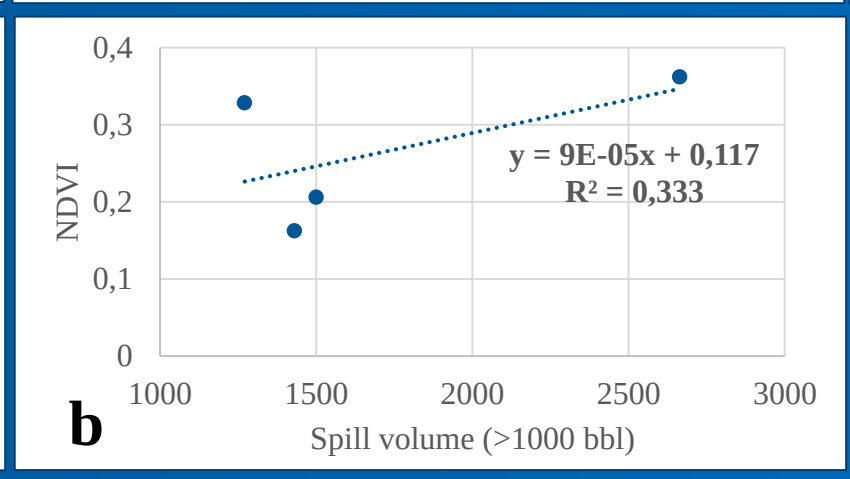












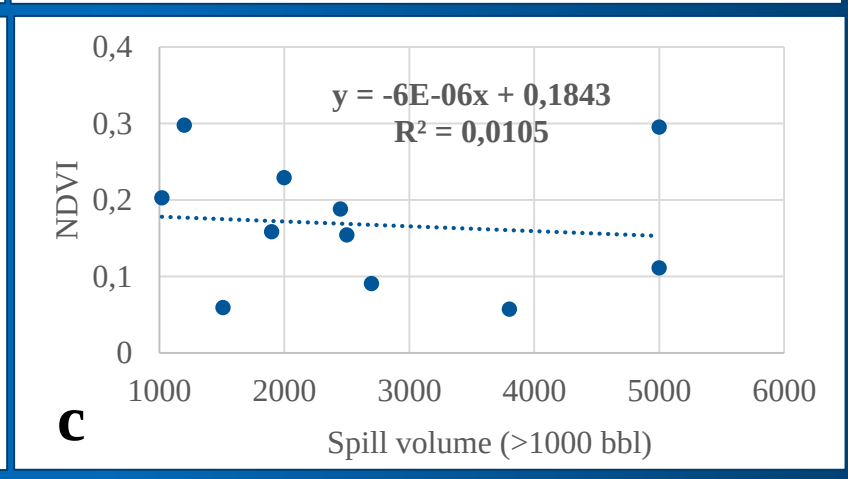


Figure 5: The relationship between NDVI and oil spill for volume (225-400 bbl in row 1; 400-1000 in row 2; >1000 bbl in row 3) for (a) DV, (b) SV and (c) MV.

Impact of volume of oil spill and time gap on the health of vegetation…cont.

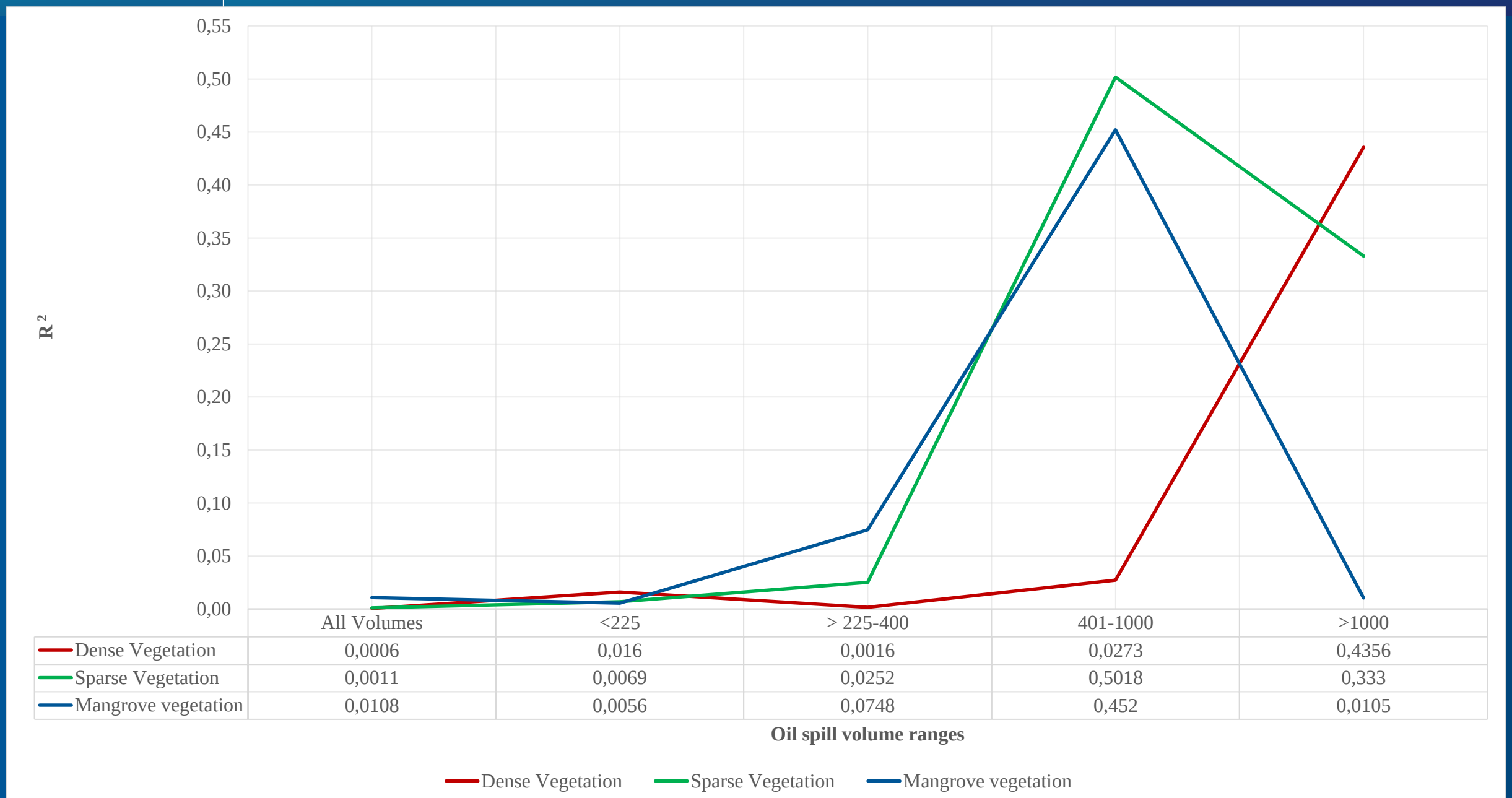


Figure 6: Linear Regression analysis results between various oil spill volumes and NDVI for different types of vegetation.

- **DV respond more to the impact of oil spills at a higher volume than the SV and MV**

Temporal response of vegetation condition following an oil spill

Table 2: Paired t-test analysis for the spill sites and control (non-spill) sites for different land cover types.

Type of Vegetation	p-values
Dense Vegetation	**
Sparse Vegetation	***
Mangrove vegetation	***

Levels of significance: *** *p*-value < 0.001 (highly significant); ** *p*-value < 0.01 (very significant); **p*-value < 0.05 (significant); ^{ns} *p*-value ≥ 0.05 (not significant).

- Sparse and mangrove vegetation are the most affected by oil spill.

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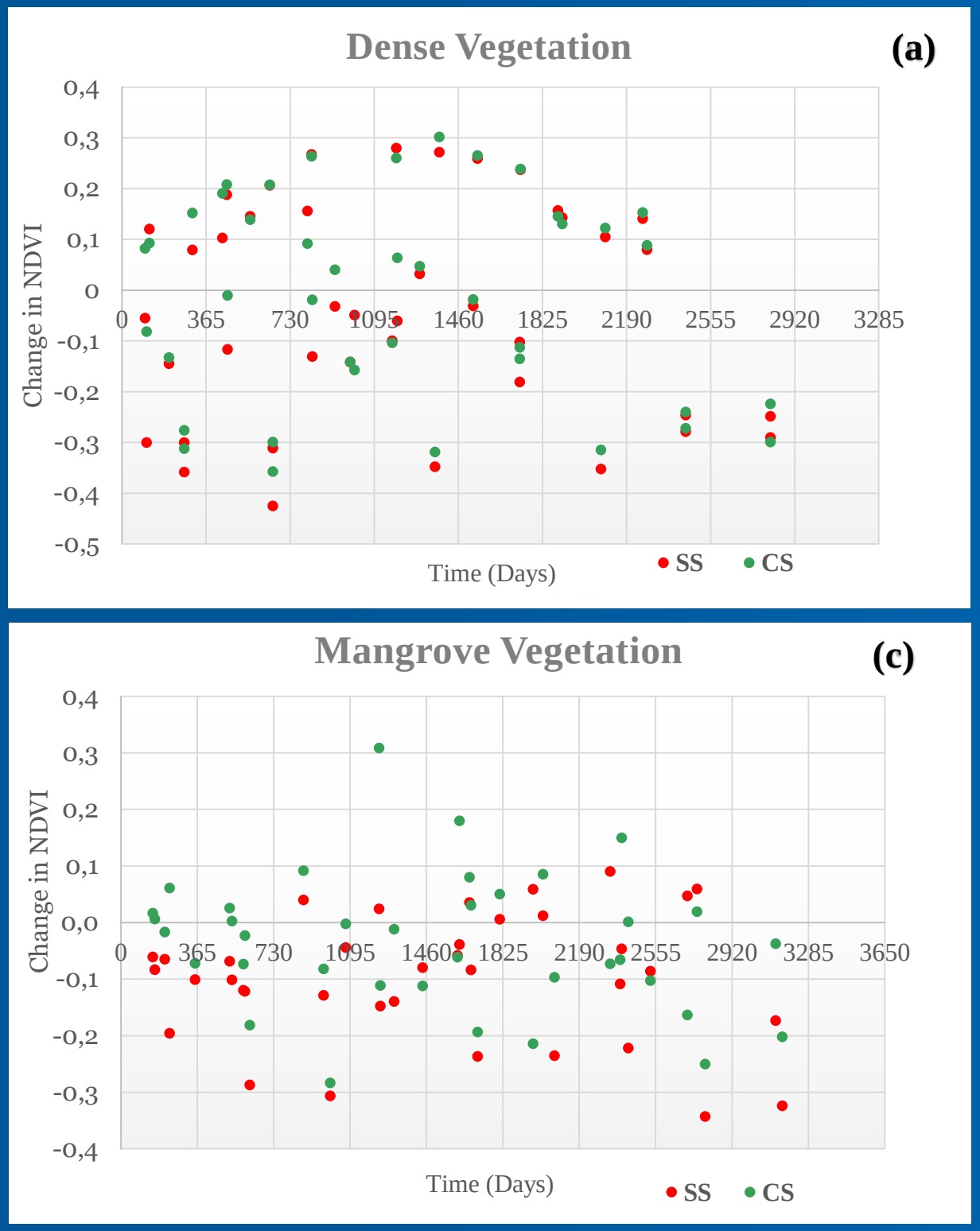
Temporal response of vegetation condition following an oil spill



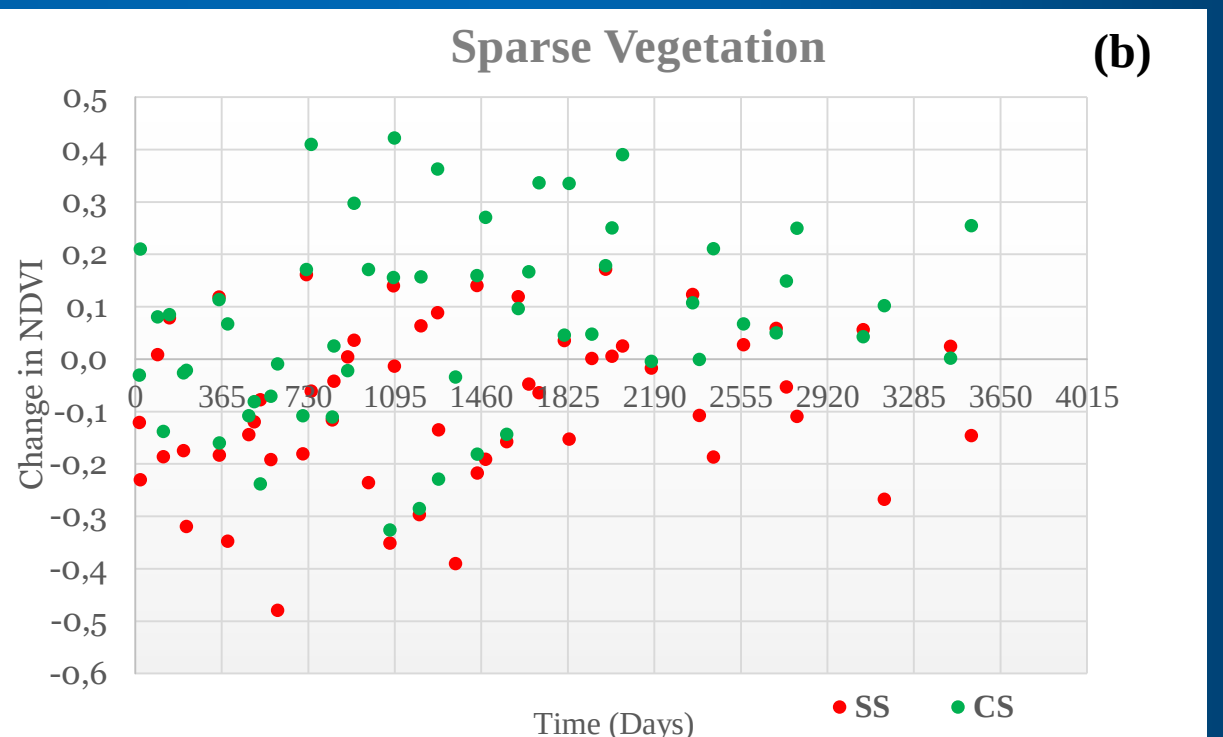


Figure 7: Relationship between change in NDVI and number of years after spill at spill sites (SS) and control sites (CS) for (a) DV, (b) SV and (c) MV.

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Temporal changes in NDVI before and after spills

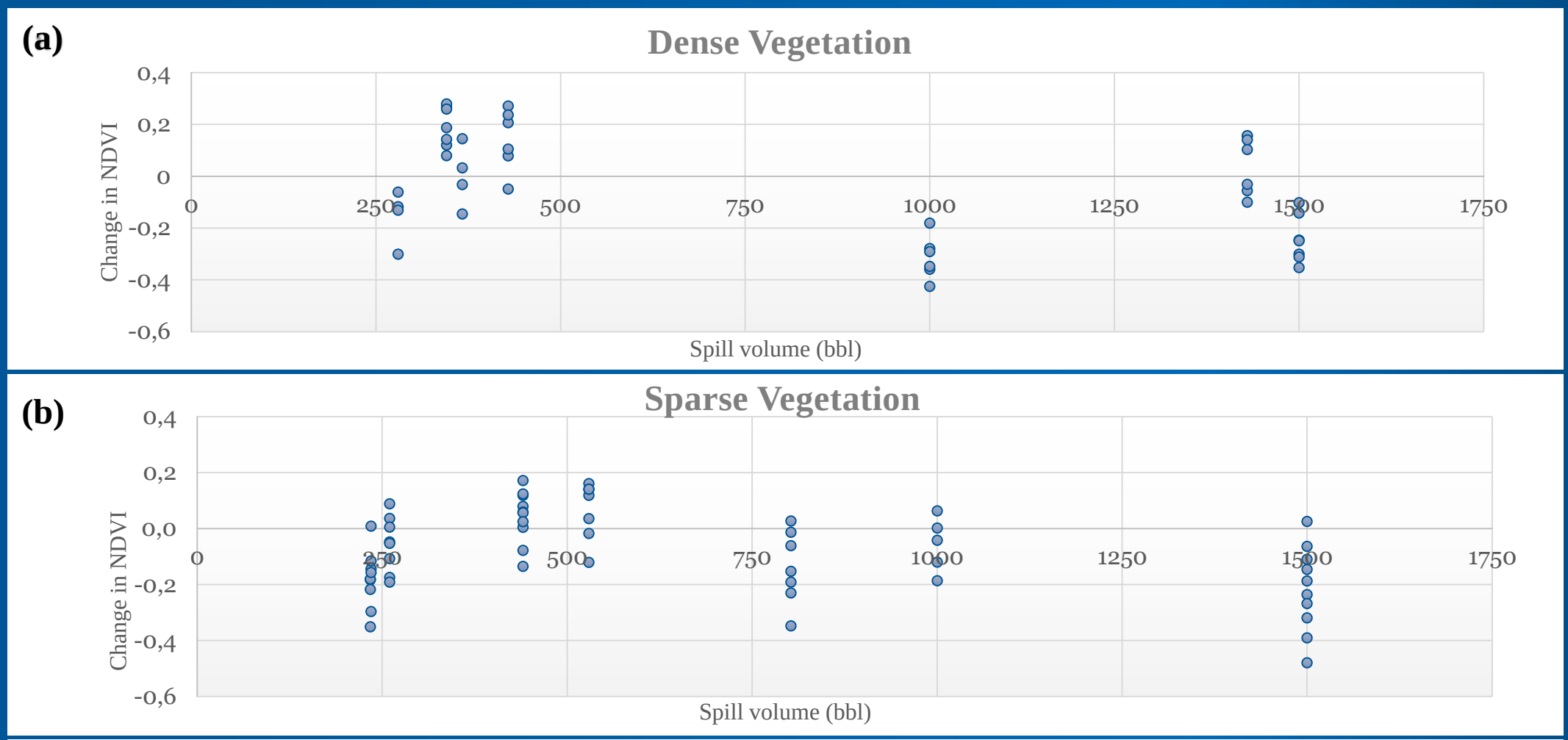

Figure 8: Relationship between change in NDVI and oil spill volume for (a) DV, (b) SV and (c) MV.

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Temporal response of vegetation condition following an oil spill…cont.

Table 3: Paired t-test analysis for each SS and CS for different vegetation cover types

VT	OSV	p-value	VT	OSV	p-value	VT	OSV	p-value
DV			SV			MV		
SSD1	280	ns	SSS1	228	*	SSM1	264	*
SSD2	345.75	ns	SSS2	235	ns	SSM2	800	ns
SSD3	367	ns	SSS3	260	**	SSM3	1020	ns
SSD4	367	ns	SSS4	440.3	ns	SSM4	1510	ns
SSD5	429	ns	SSS5	529.5	ns	SSM5	1554	**
SSD6	1000	ns	SSS6	802.5	**	SSM6	2500	*
SSD7	1430	ns	SSS7	1000	*			
SSD8	1500	ns	SSS8	1500	**			

Note: VT = Vegetation type; OSV = Oil spill volume (bbl).
Levels of significance: *** *p*-value < 0.001 (highly significant); ** *p*-value < 0.01 (very significant); *p-value < 0.05 (significant); ^{ns} p-value ≥ 0.05 (not significant).

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Conclusion

- Different types of vegetation respond differently to various volumes of oil spill, with sparse vegetation being the most affected among the three types of vegetation.

- Dense vegetation responds to higher volume oil spills, while the mangrove shows earlier signs of stress than the other types.

- The results could help in designing a vegetation-specific oil spill cleanup program to mitigate the impact of oil spills in the Niger Delta region.

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