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Residential Greenness and Birth Outcomes: Evaluating the Influence of Spatially Correlated Built-Environment Factors

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Background: Half the world's population lives in urban areas. It is therefore important to identify characteristics of the built environment that are beneficial to human health. Urban greenness has been associated with improvements in a diverse range of health conditions, including birth outcomes; however, few studies have attempted to distinguish potential effects of greenness from those of other spatially correlated exposures related to the built environment.

Objectives: We aimed to investigate associations between residential greenness and birth outcomes and evaluate the influence of spatially correlated built environment factors on these associations.

Methods: We examined associations between residential greenness [measured using satellite-derived Normalized Difference Vegetation Index (NDVI) within 100 m of study participants' homes] and birth outcomes in a cohort of 64,705 singleton births (from 1999–2002) in Vancouver, British Columbia, Canada. We also evaluated associations after adjusting for spatially correlated built environmental factors that may influence birth outcomes, including exposure to air pollution and noise, neighborhood walkability, and distance to the nearest park.

Results: An interquartile increase in greenness (0.1 in residential NDVI) was associated with higher term birth weight (20.6 g; 95% CI: 16.5, 24.7) and decreases in the likelihood of small for gestational age, very preterm (< 30 weeks), and moderately preterm (30–36 weeks) birth. Associations were robust to adjustment for air pollution and noise exposures, neighborhood walkability, and park proximity.

Conclusions: Increased residential greenness was associated with beneficial birth outcomes in this population-based cohort. These associations did not change after adjusting for other spatially correlated built environment factors, suggesting that alternative pathways (e.g., psychosocial and psychological mechanisms) may underlie associations between residential greenness and birth outcomes.

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Introduction

More than half of the world's population now live in urban environments, and it has been estimated that by 2050 this number will grow to 60% (approximately 6.4 billion people) (World Health Organization 2013). A diverse range of characteristics associated with living in urban environments—ranging from environmental hazards to social support to health care services—are important to health (Vlahov et al. 2007). Recently, a growing body of evidence has linked exposure to urban greenness (also referred to as green space or natural environments) with measures of health, including mortality (Donovan et al. 2013; Mitchell and Popham 2008; Takano et al. 2002; Villeneuve et al. 2012), respiratory illness (Villeneuve et al. 2012), well-being (Groenewegen et al. 2006; Lafortezza et al. 2009; Maas et al. 2006), and mental health (Sugiyama et al. 2008; Van den Berg et al. 2010; Ward Thompson et al. 2012).

Only a few studies have examined associations between exposure to residential greenness during pregnancy and birth outcomes. Adverse birth outcomes, such as preterm birth and low birth weight, are important not only because of their immediate impacts on infant health but also because of the subsequent health and developmental consequences through the individual's life course (Blumenshine et al. 2010). In Portland, Oregon, a study of 5,295 births observed that a 10% increase in tree-canopy cover within 50 m of a residence was associated with a significant decrease in small for gestational age (SGA) births [odds ratio (OR) = 0.85; 95% CI: 0.76, 0.94], with no association observed for preterm births (Donovan et al. 2011). A study of 2,393 births from four Spanish cohorts observed similar relationships (Dadvand et al. 2012c). An interquartile range (IQR) increase in average greenness [assessed using satellite-based Normalized Difference Vegetation index (NDVI)] within 500 m of residences was associated with an increase in birth weight of 44.2 g (95% CI: 20.2, 68.2) and an increase in head circumference of 1.7 mm (95% CI: 0.5, 2.9). No associations were observed with measures of gestational age. In another cohort of 8,246 births in Barcelona, Spain, NDVI within 100 m of residences was not associated with birth weight or gestational age in the entire cohort; but in the group with the lowest educational attainment, increasing greenness was associated with higher birth weight (Dadvand et al. 2012a). Finally, for 3,203 births in Munich, Germany, between 1996 and 1999, an IQR increase in greenness within 500 m of residences was associated with a 17.6-g (95% CI: 0.5, 34.6) higher mean birth weight (Markevych et al. 2014).

Given this suggestive evidence and the large potential burden accompanying adverse birth outcomes, it is important to evaluate the robustness of the association between greenness and pregnancy outcomes and the specific pathways through which potential effects may operate. In particular, there is a need to distinguish the effect of residential greenness from other spatially correlated built-environment factors. Here we define built environment as urban design, land use, and the transportation system, encompassing patterns of human activity within the physical environment (Handy et al. 2002). There are four general pathways by which we hypothesize greenness may influence birth outcomes: 1) through the reduction of harmful environmental exposures such as air and noise pollution (e.g., Dadvand et al. 2012b); 2) by providing space for increased utilitarian and recreational physical activity (e.g., Sugiyama et al. 2008); 3) by providing a setting for psychosocial influences, such as increased social contacts and community belonging (e.g., Fan et al. 2011); and 4) through directly reducing psychological stress and depression (e.g., Ward Thompson

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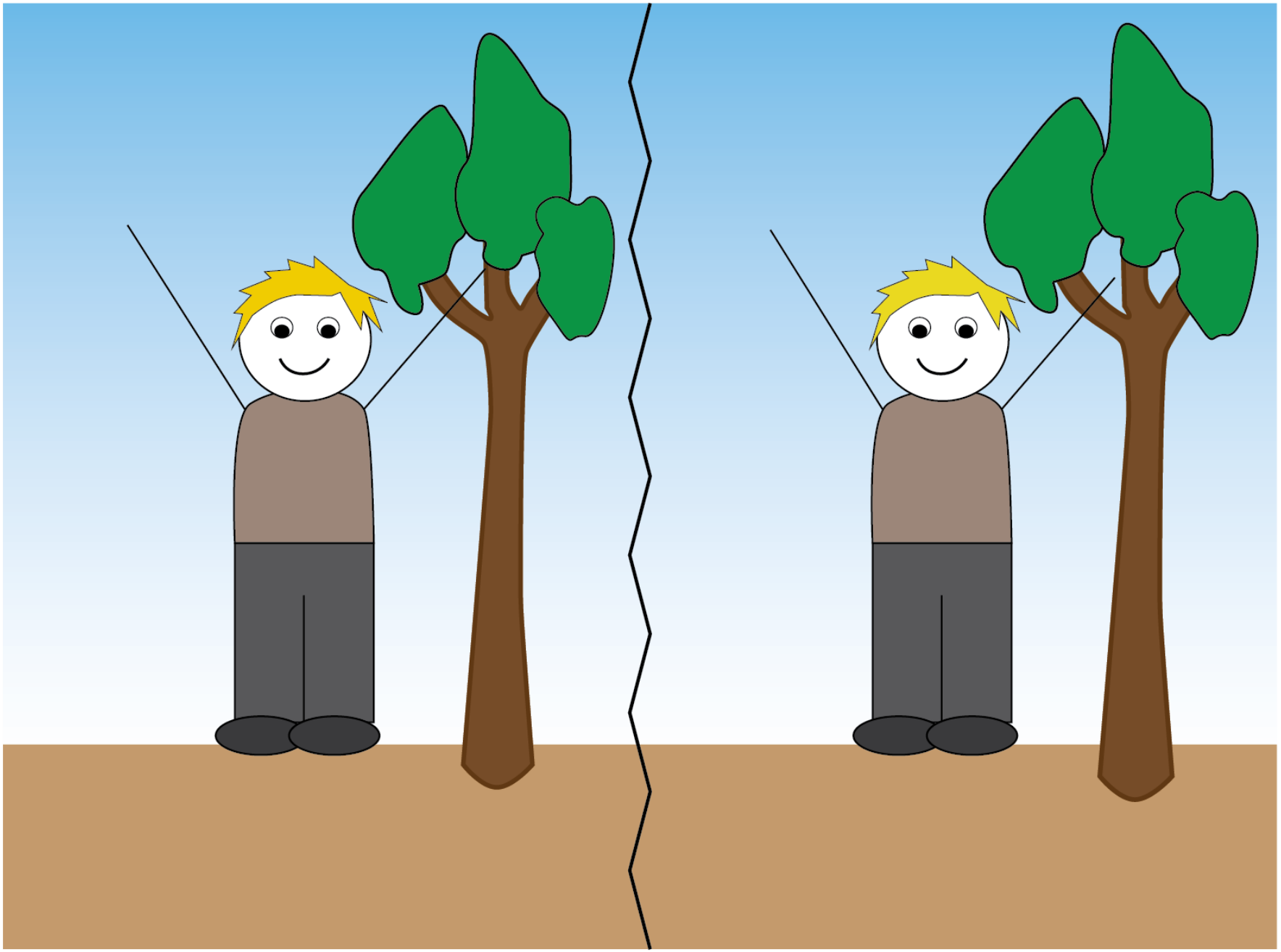

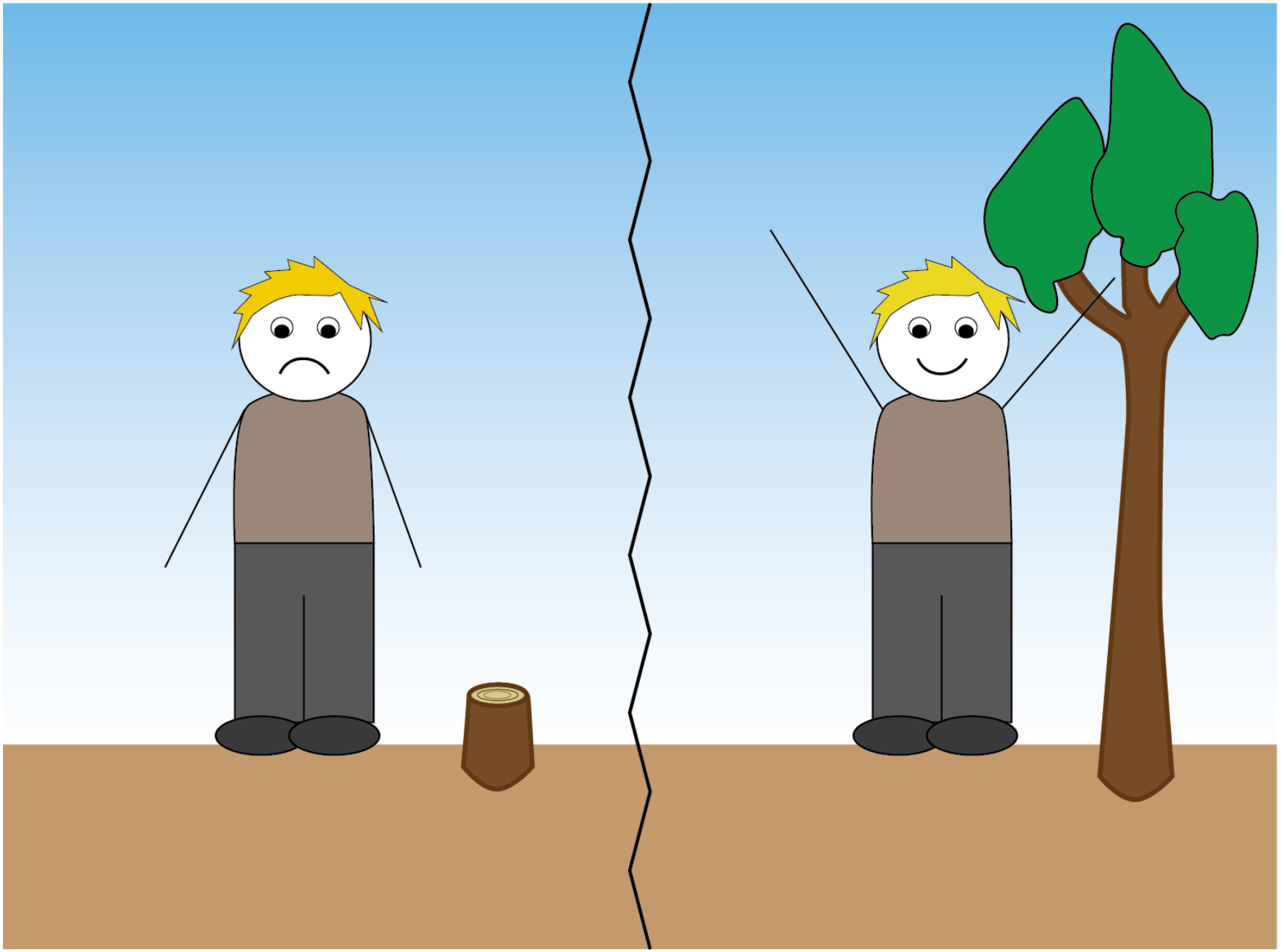


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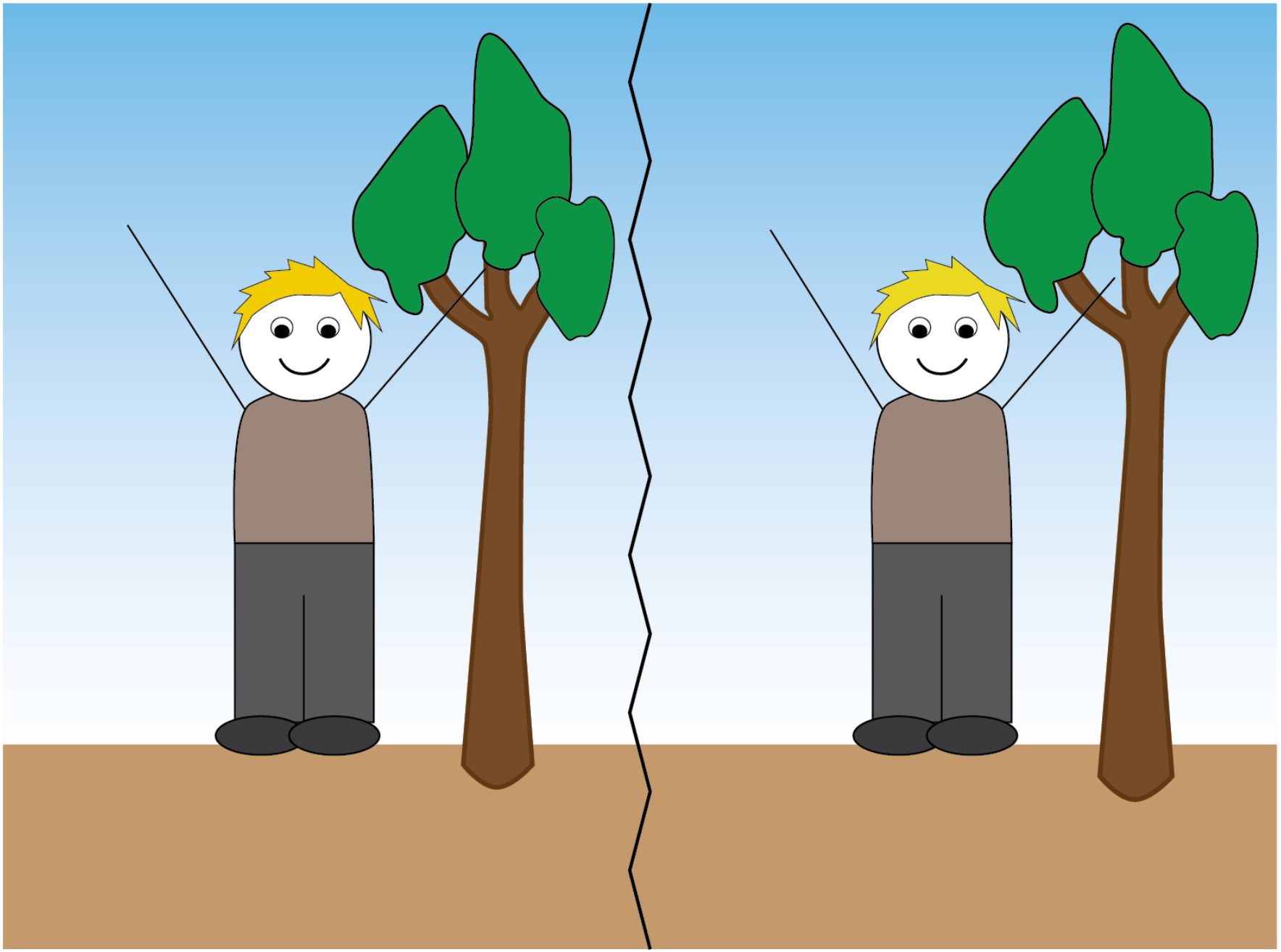

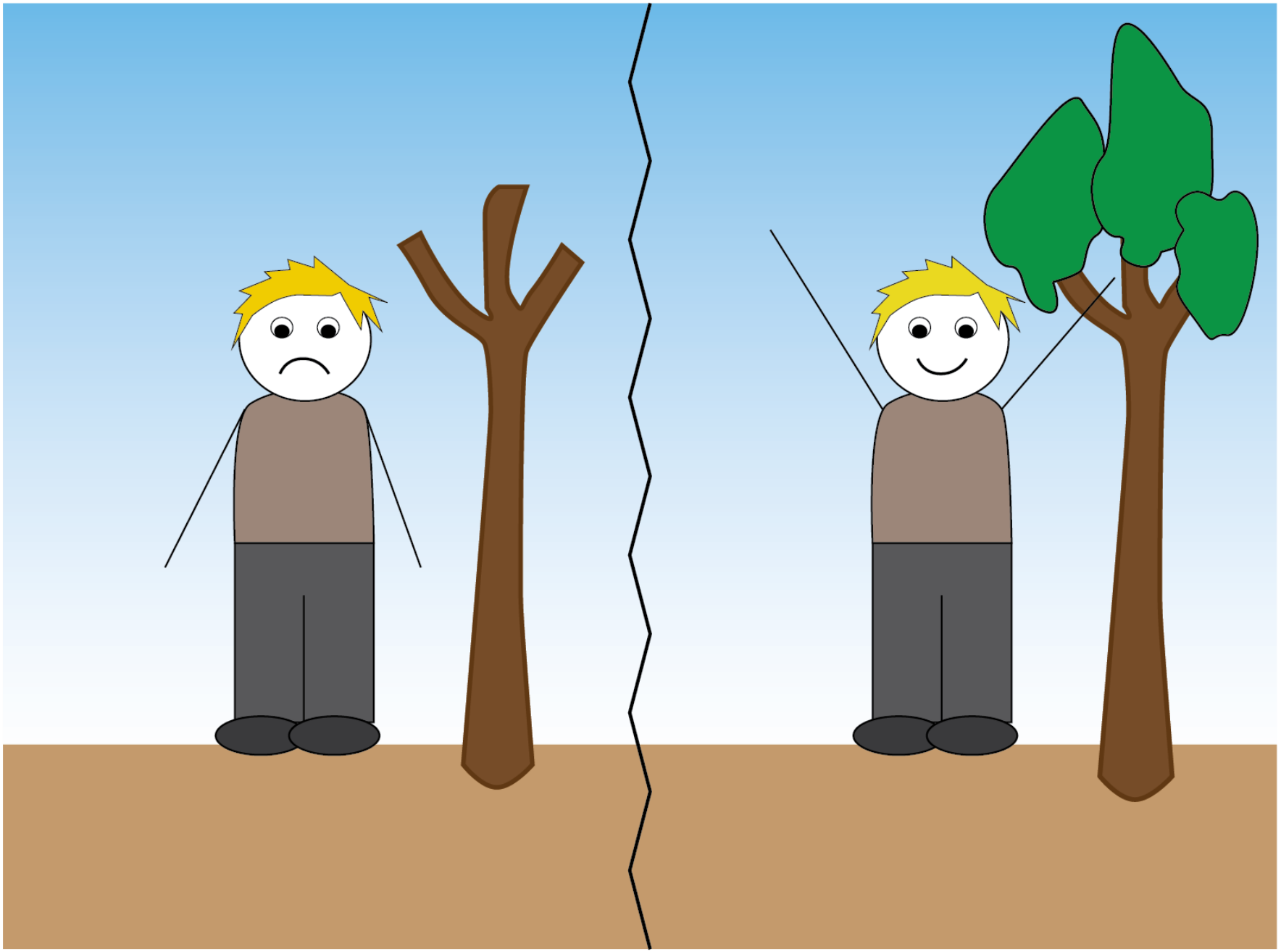

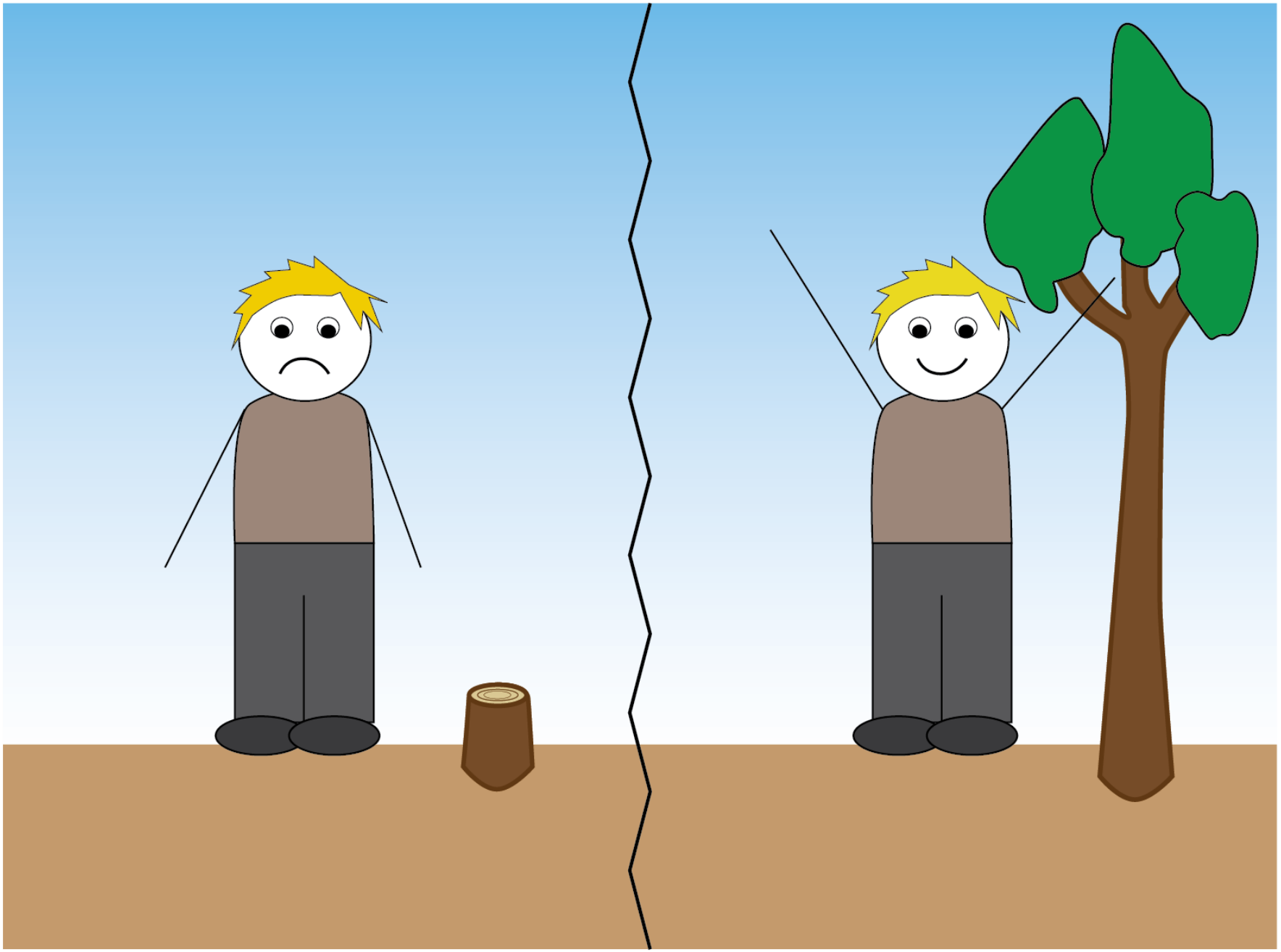

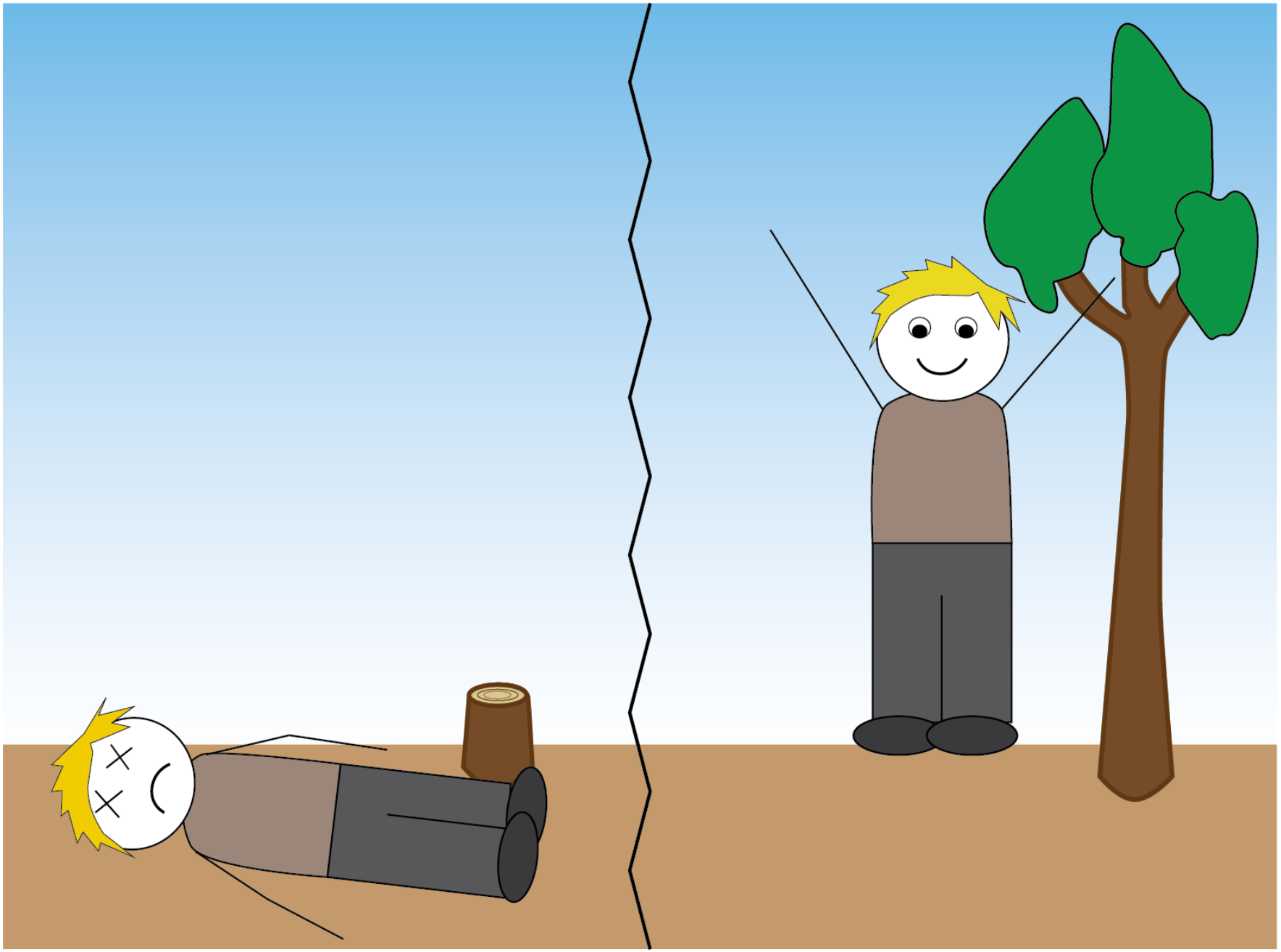

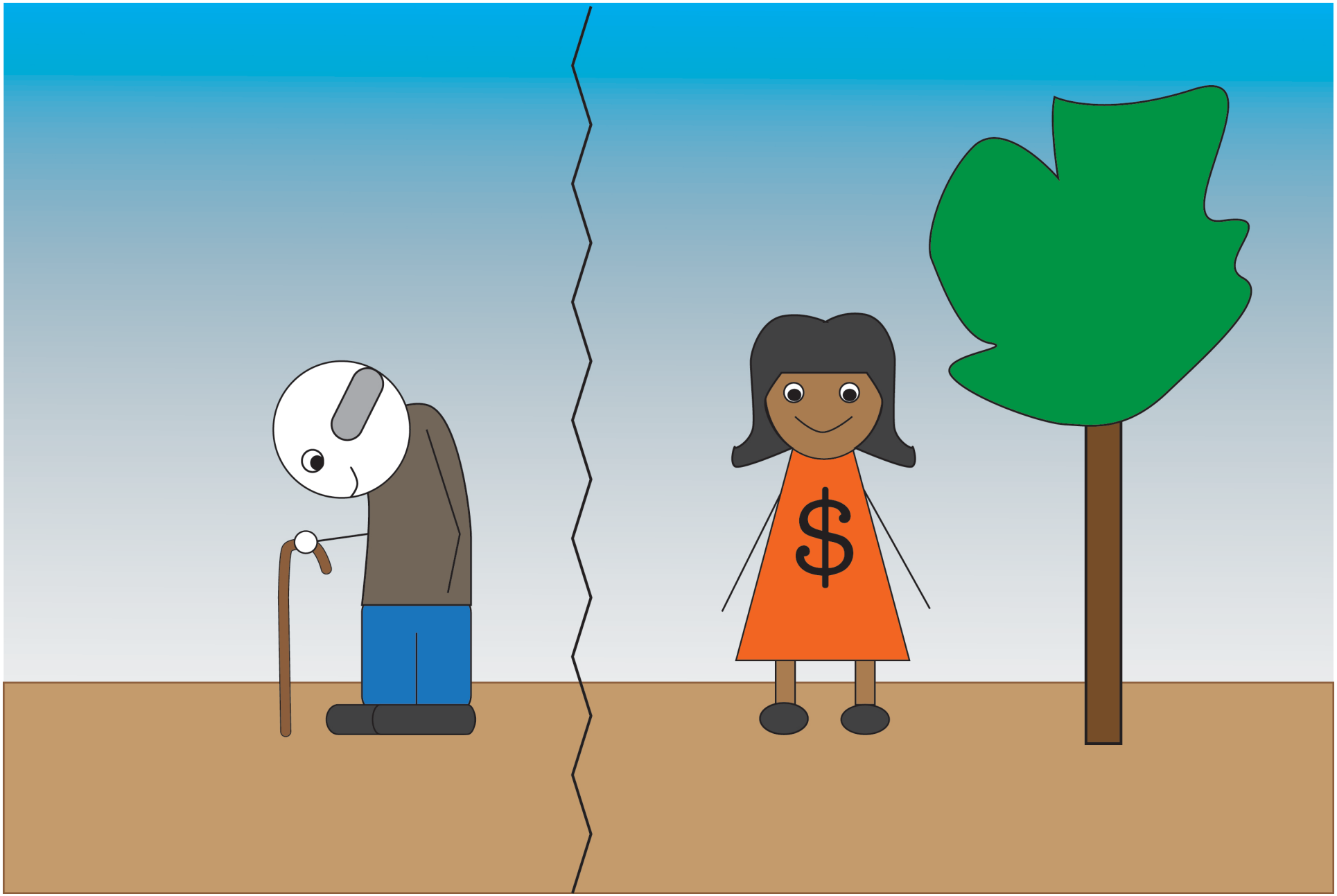

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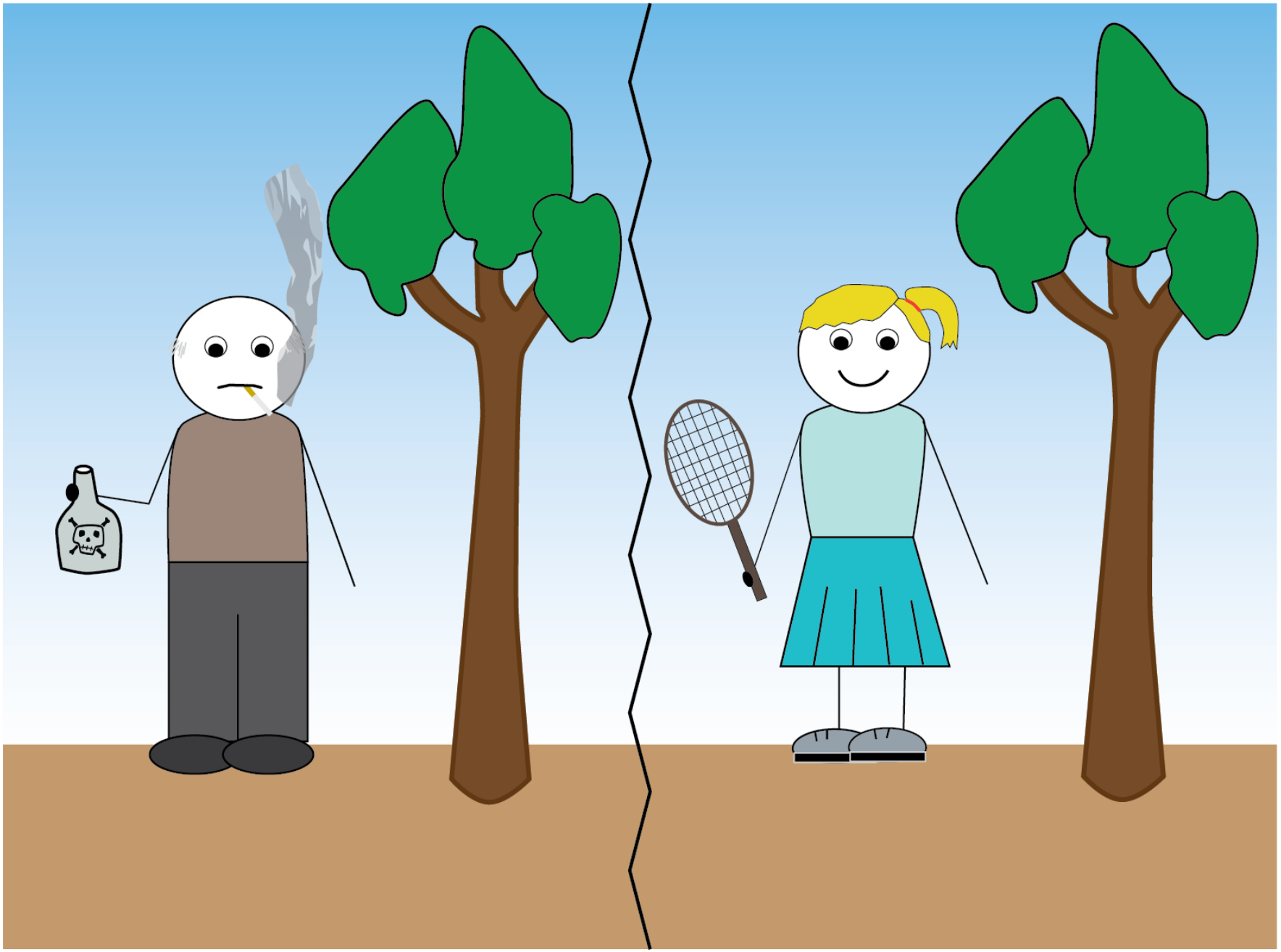

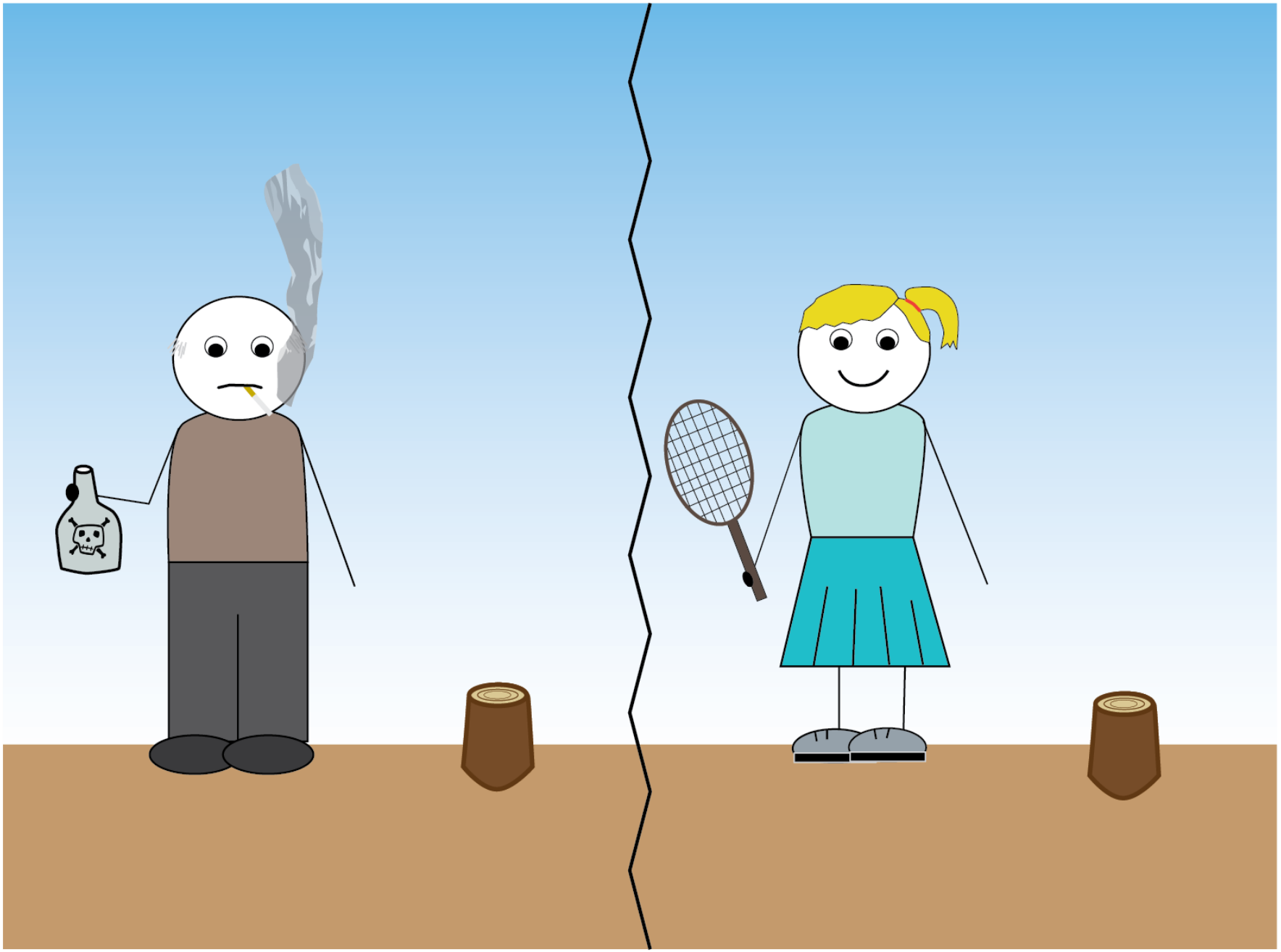

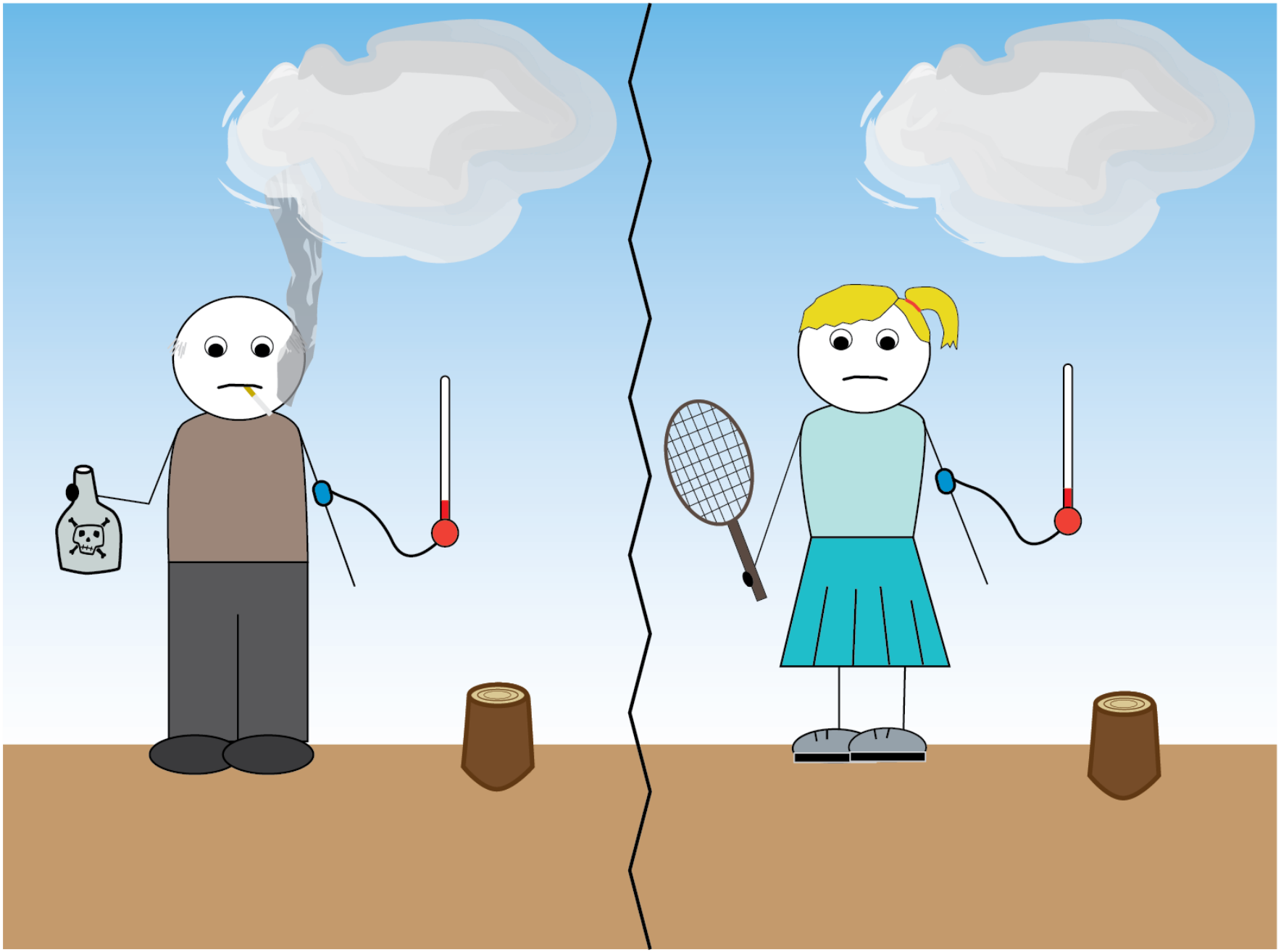

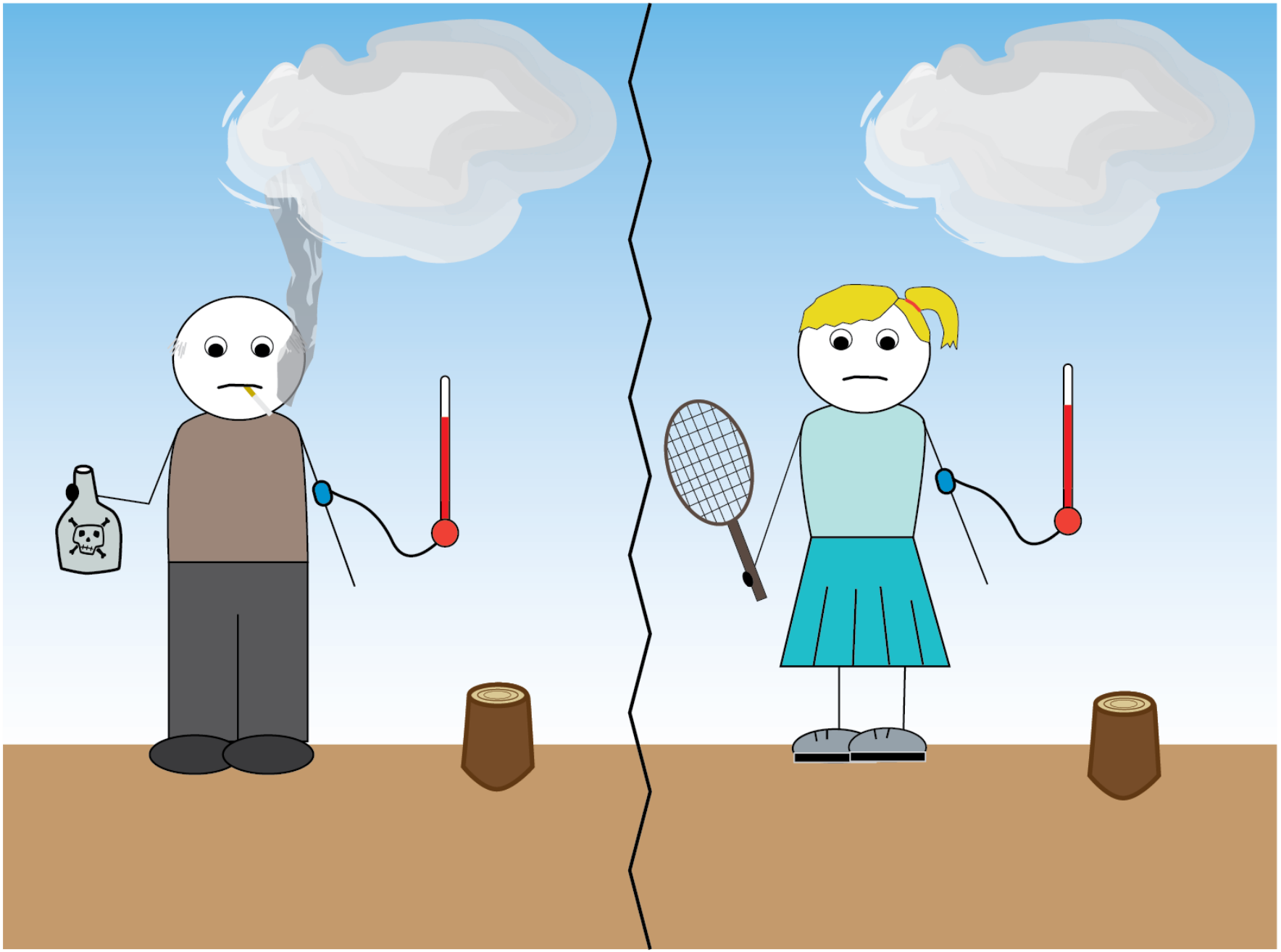

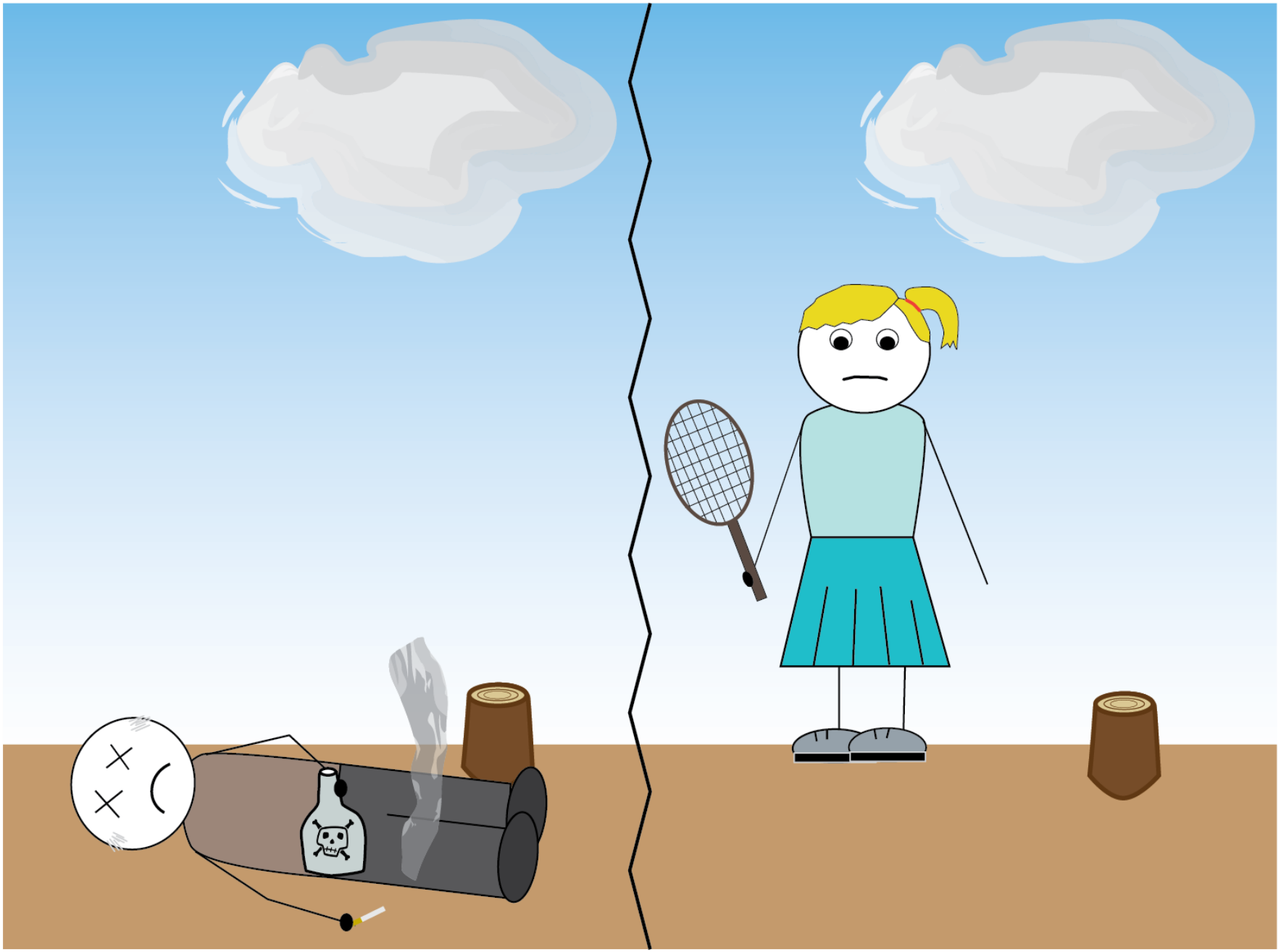


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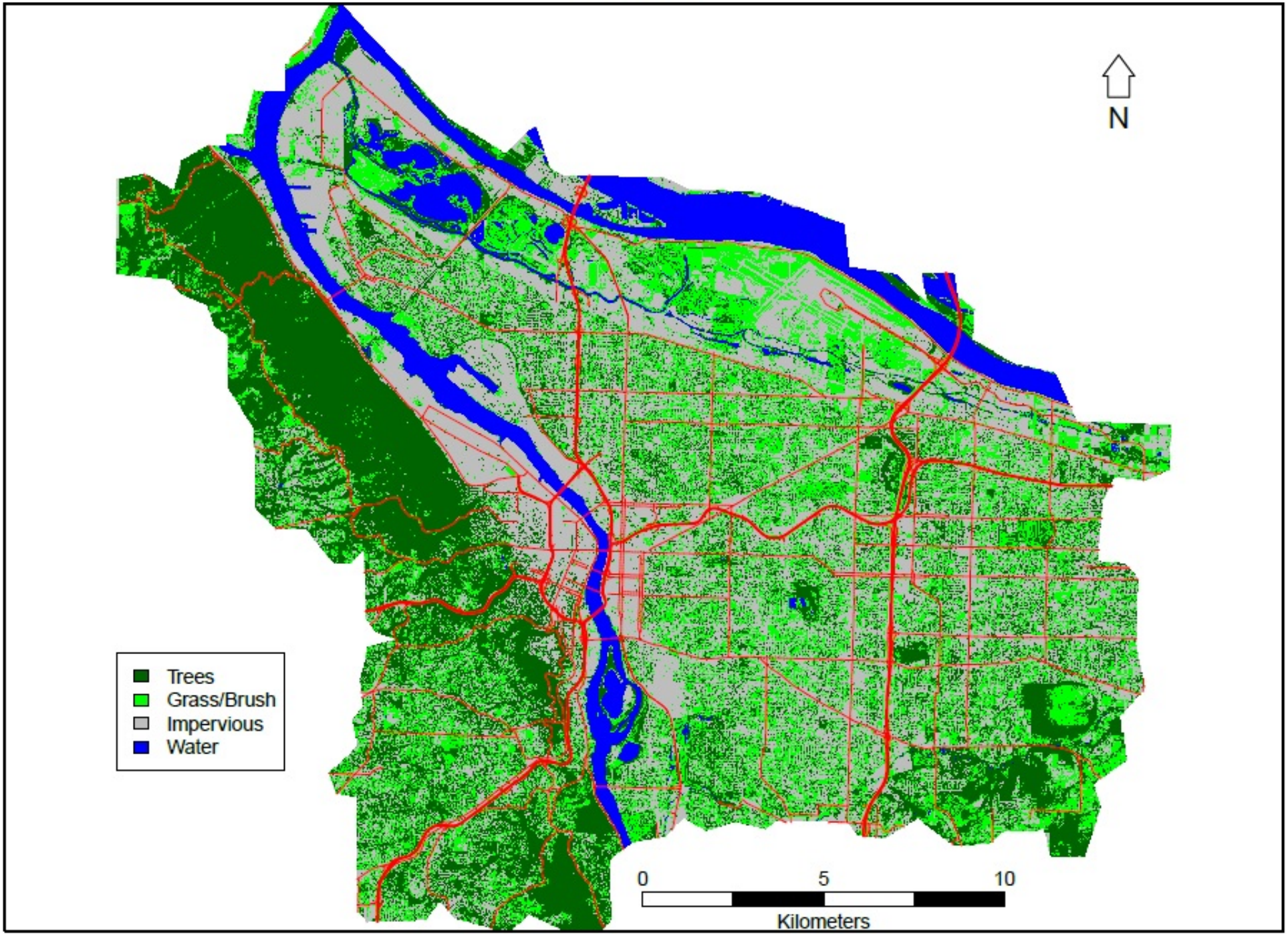

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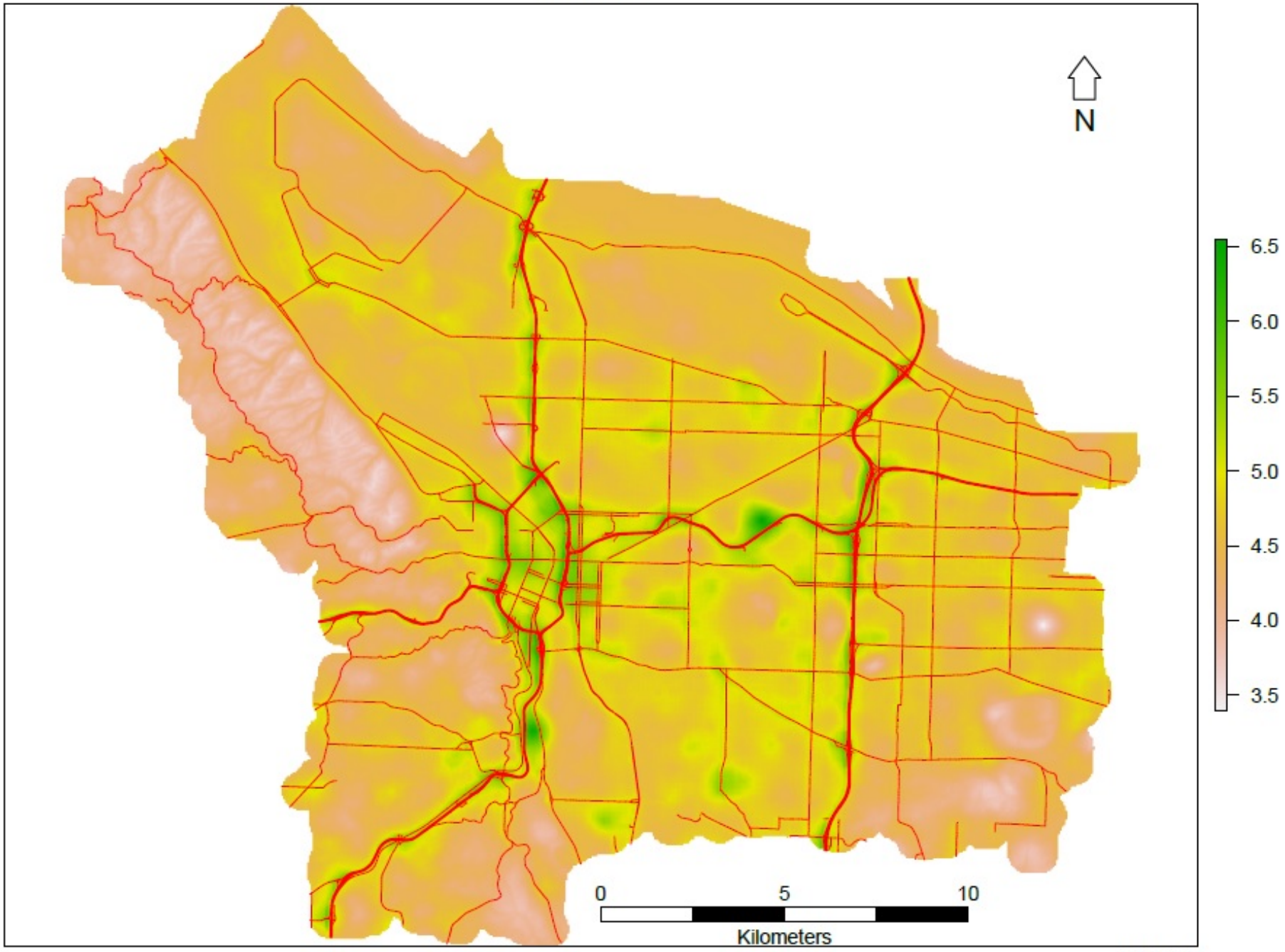

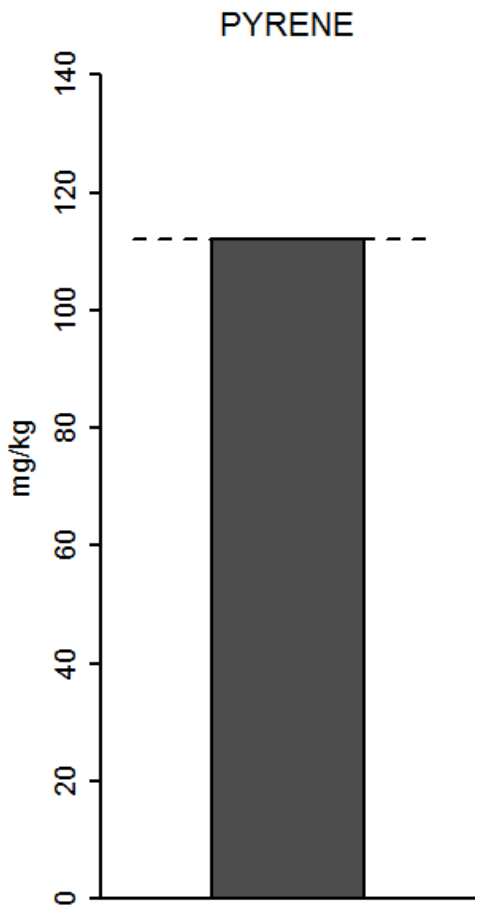
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mg/kg
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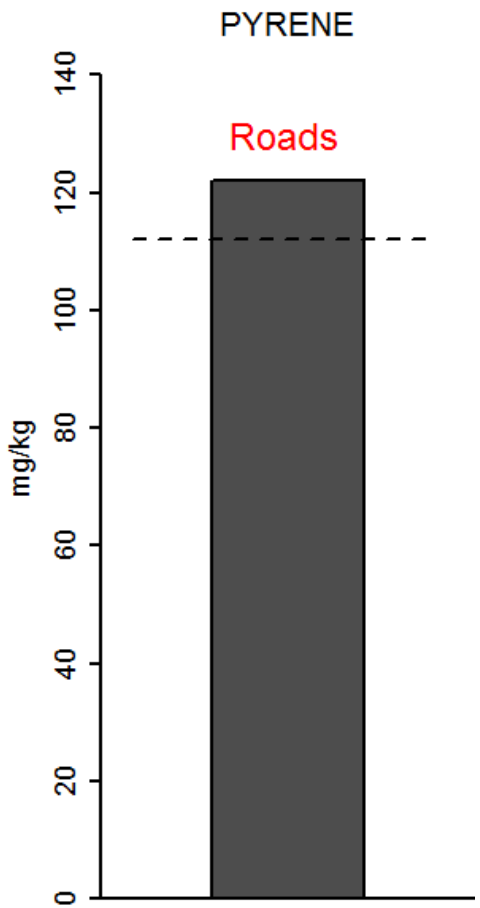
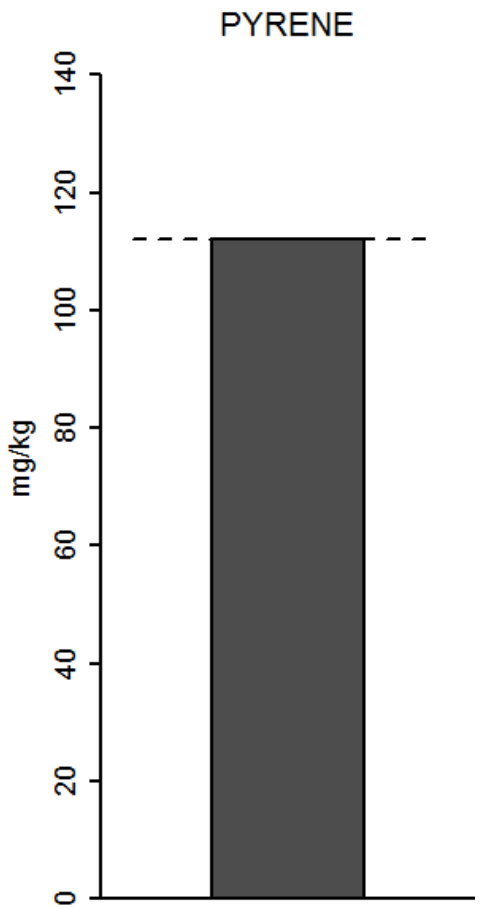
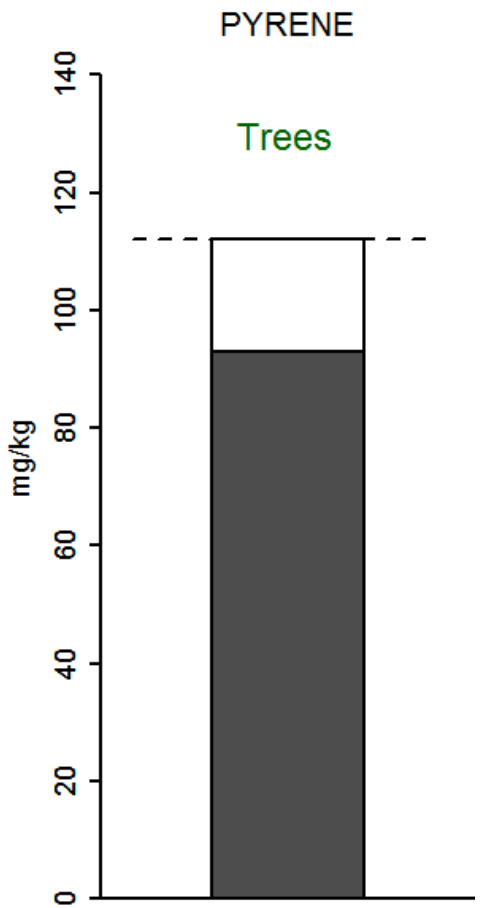
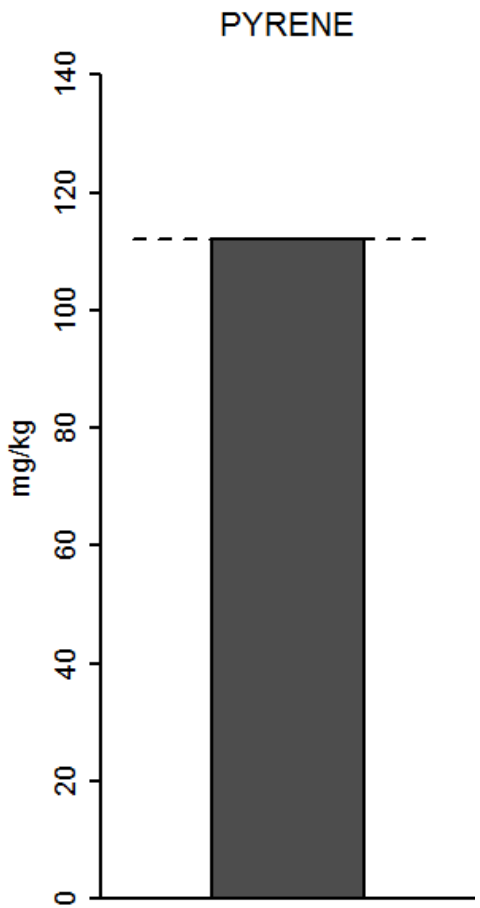
20
40
60
80
100
120
140


PYRENE
Roads
mg/kg
0
20
40
60
80
100
120
140


PYRENE
mg/kg
0
20
40
60
80
100
120
140


PYRENE
Trees
mg/kg
0
20
40
60
80
100
120
140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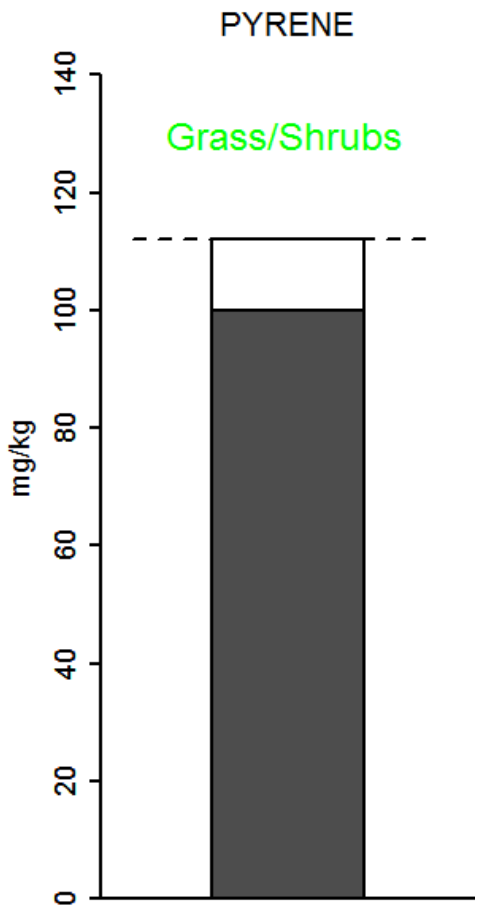
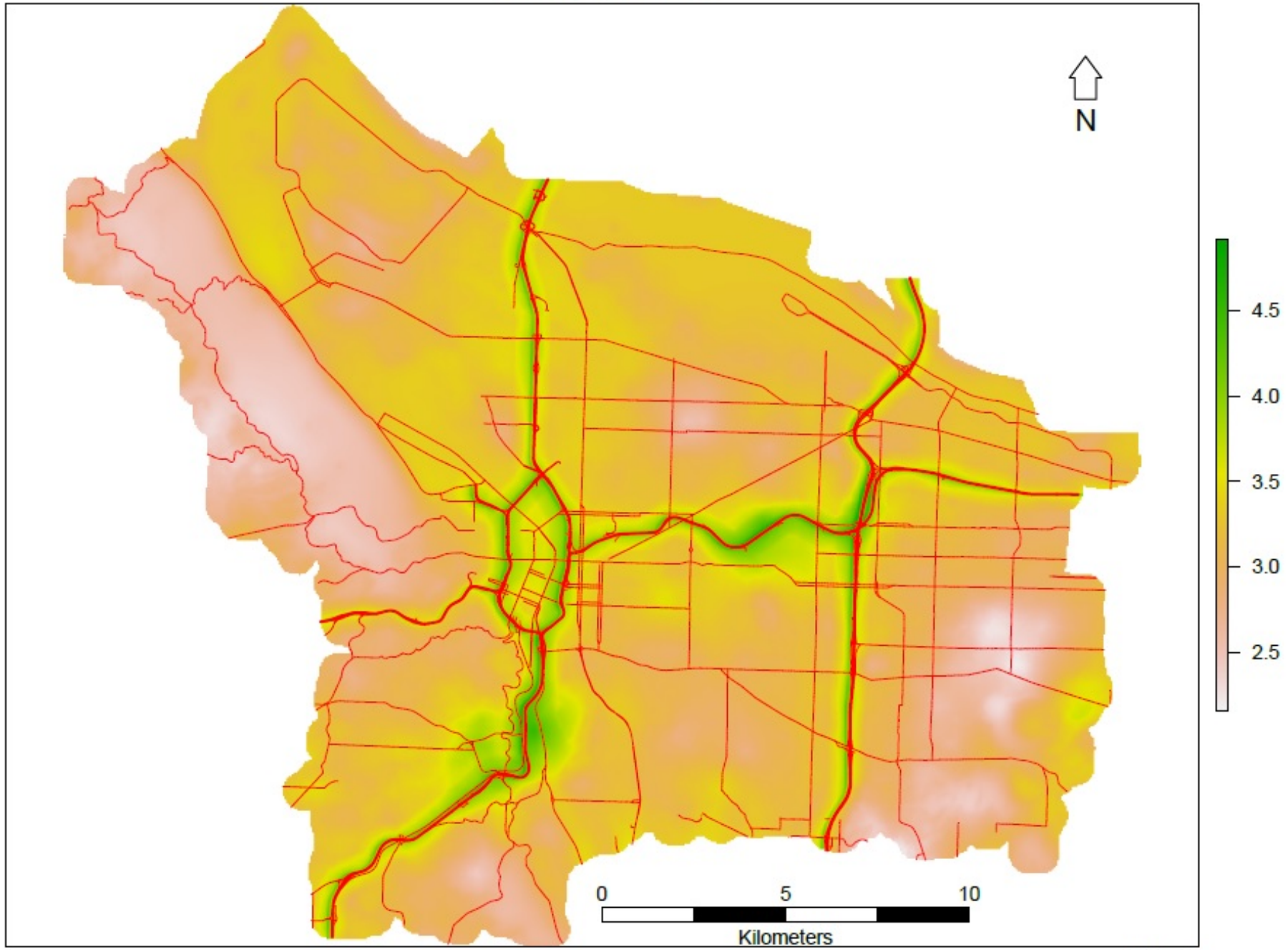
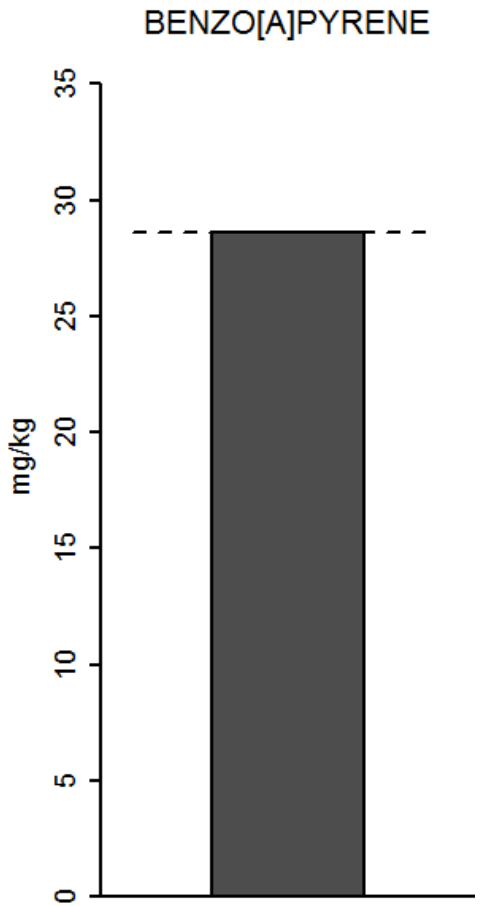
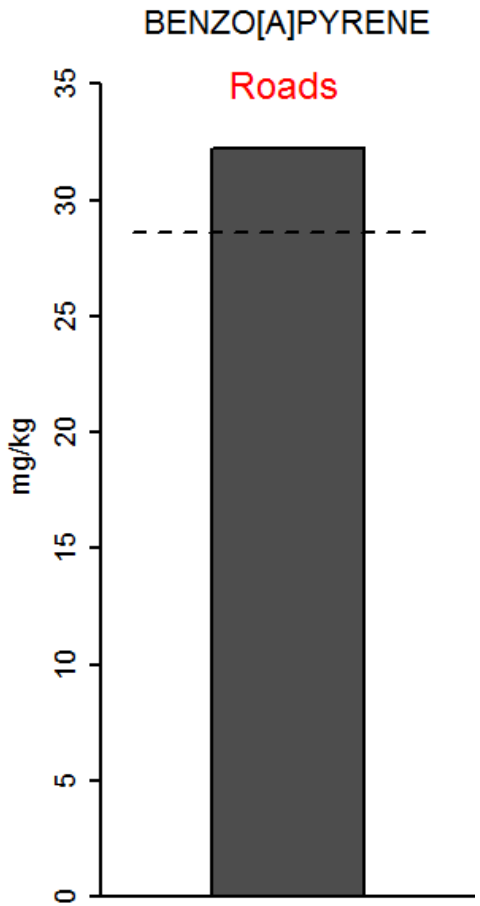
mg/kg
0
20
40
60
80
100
120
140

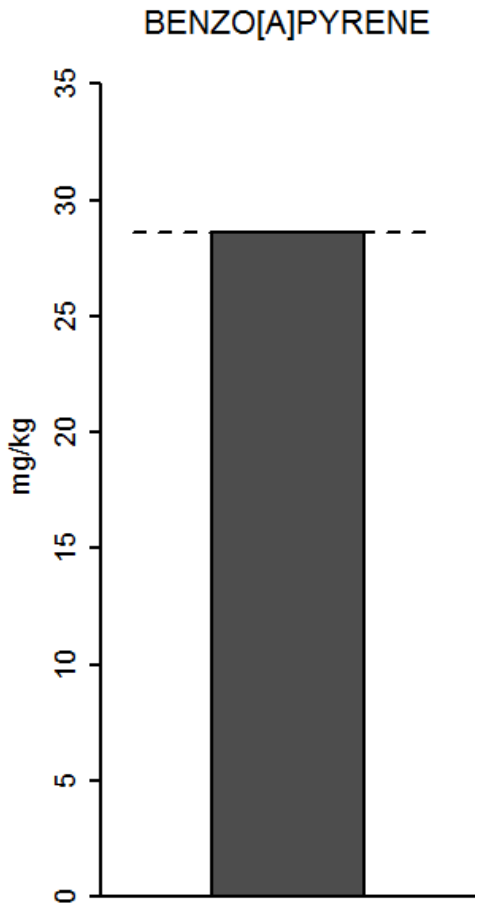

PYRENE
Grass/Shrubs
mg/kg
0
20
40
60
80
100
120
140

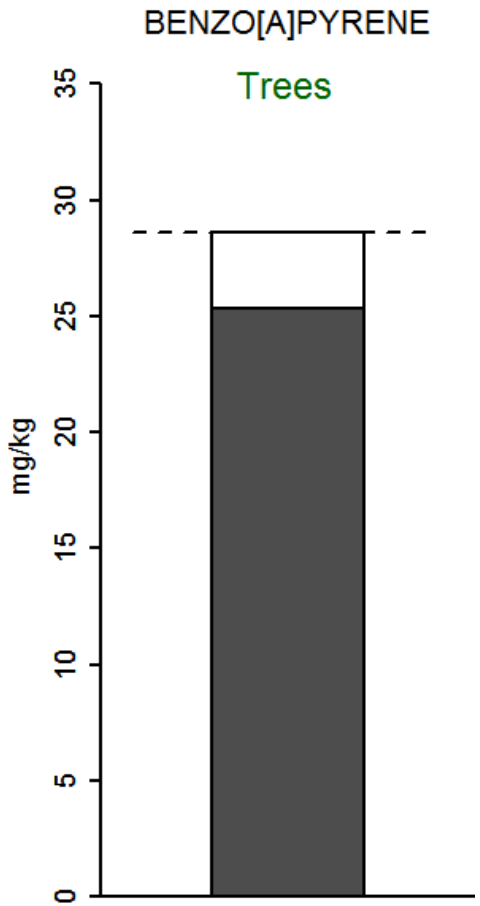
BENZO(A)PYRENE




BENZO[A]PYRENE
mg/kg
0
5
10
15
20
25
30
35


BENZO[A]PYRENE
Roads
mg/kg
0
5
10
15
20
25
30
35


BENZO[A]PYRENE
mg/kg
0
5
10
15
20
25
30
35


BENZO[A]PYRENE
Trees
mg/kg
0
5
10
15
20
25
30
35

Cadmium in moss