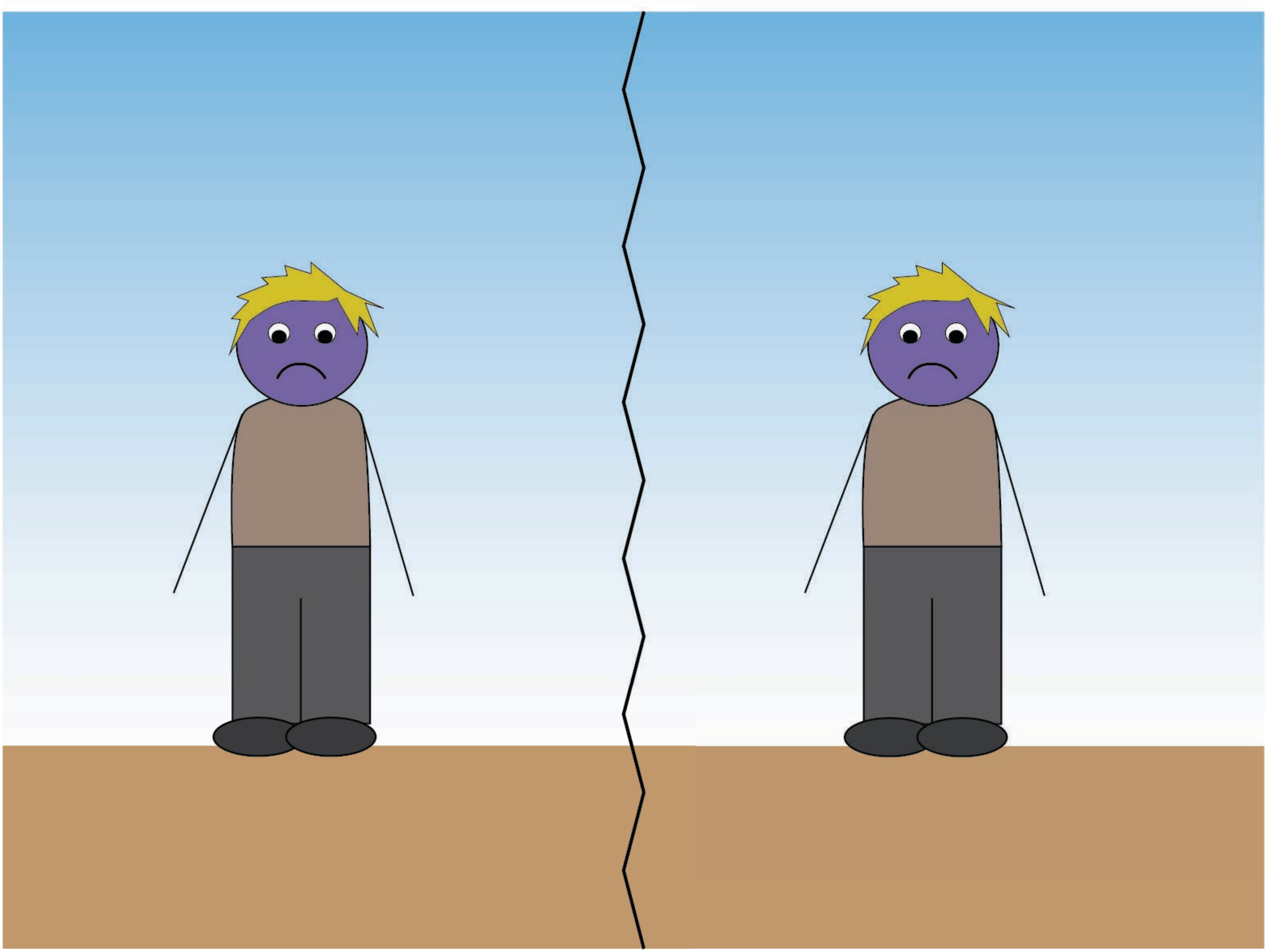

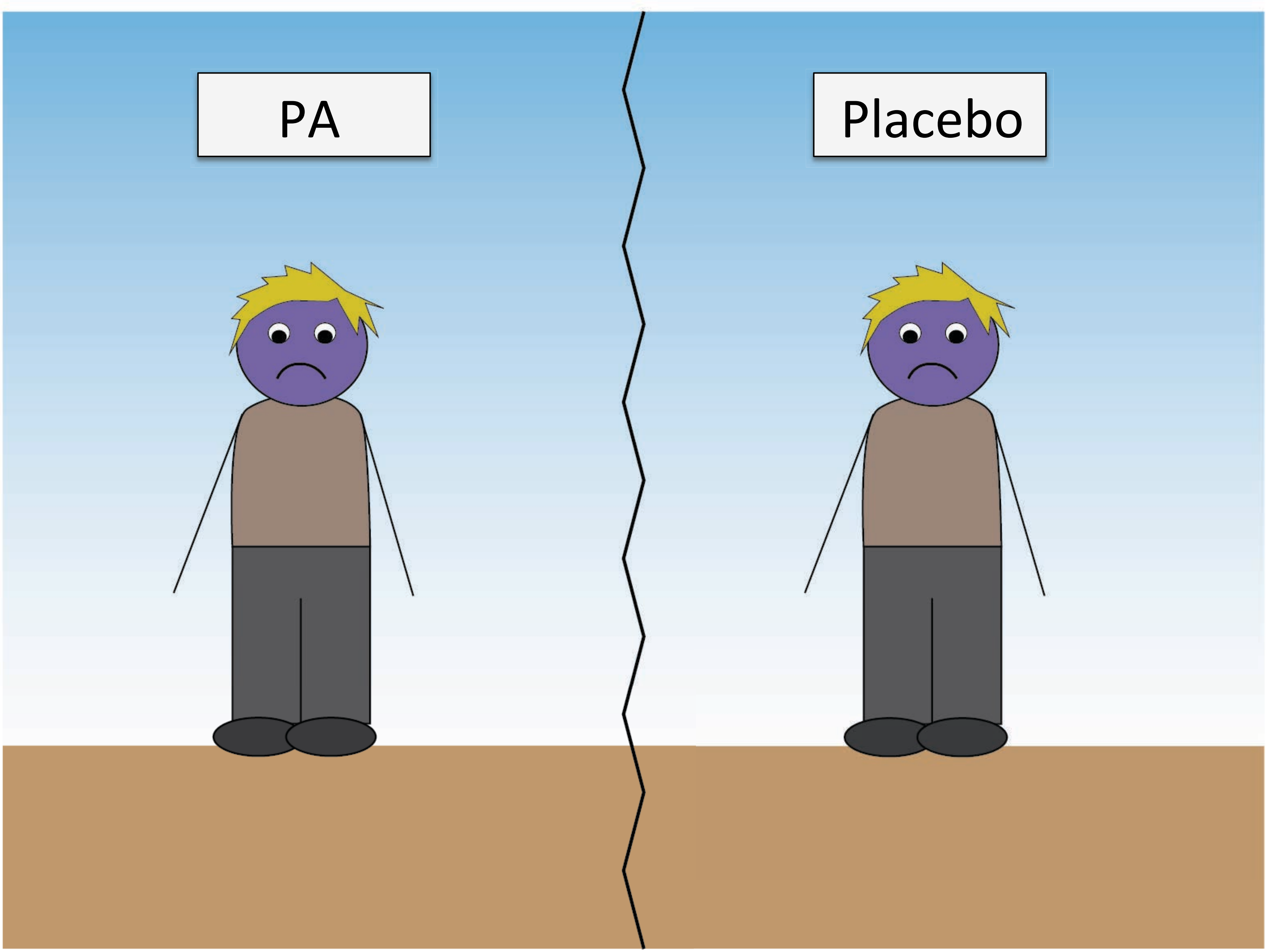
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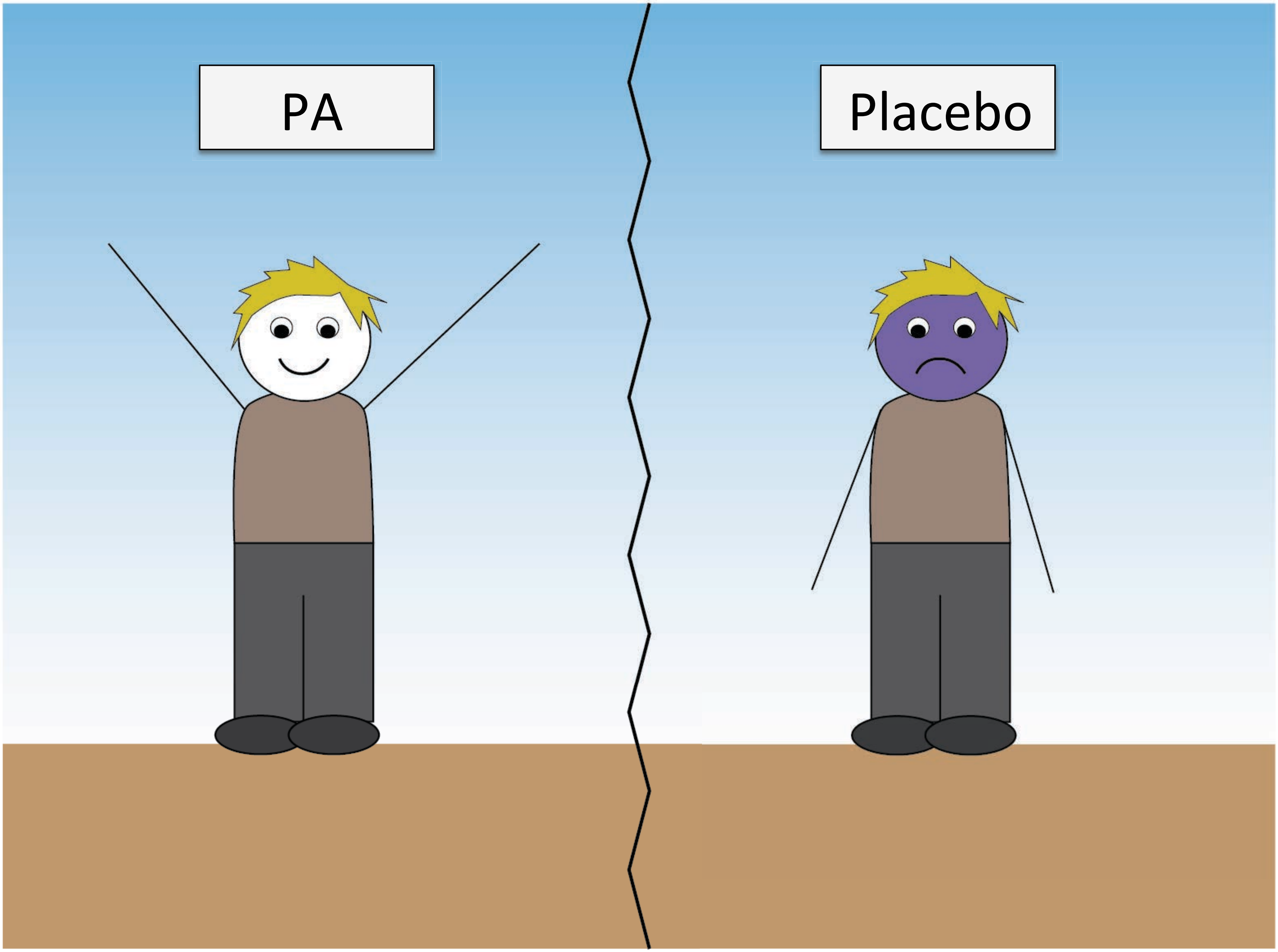
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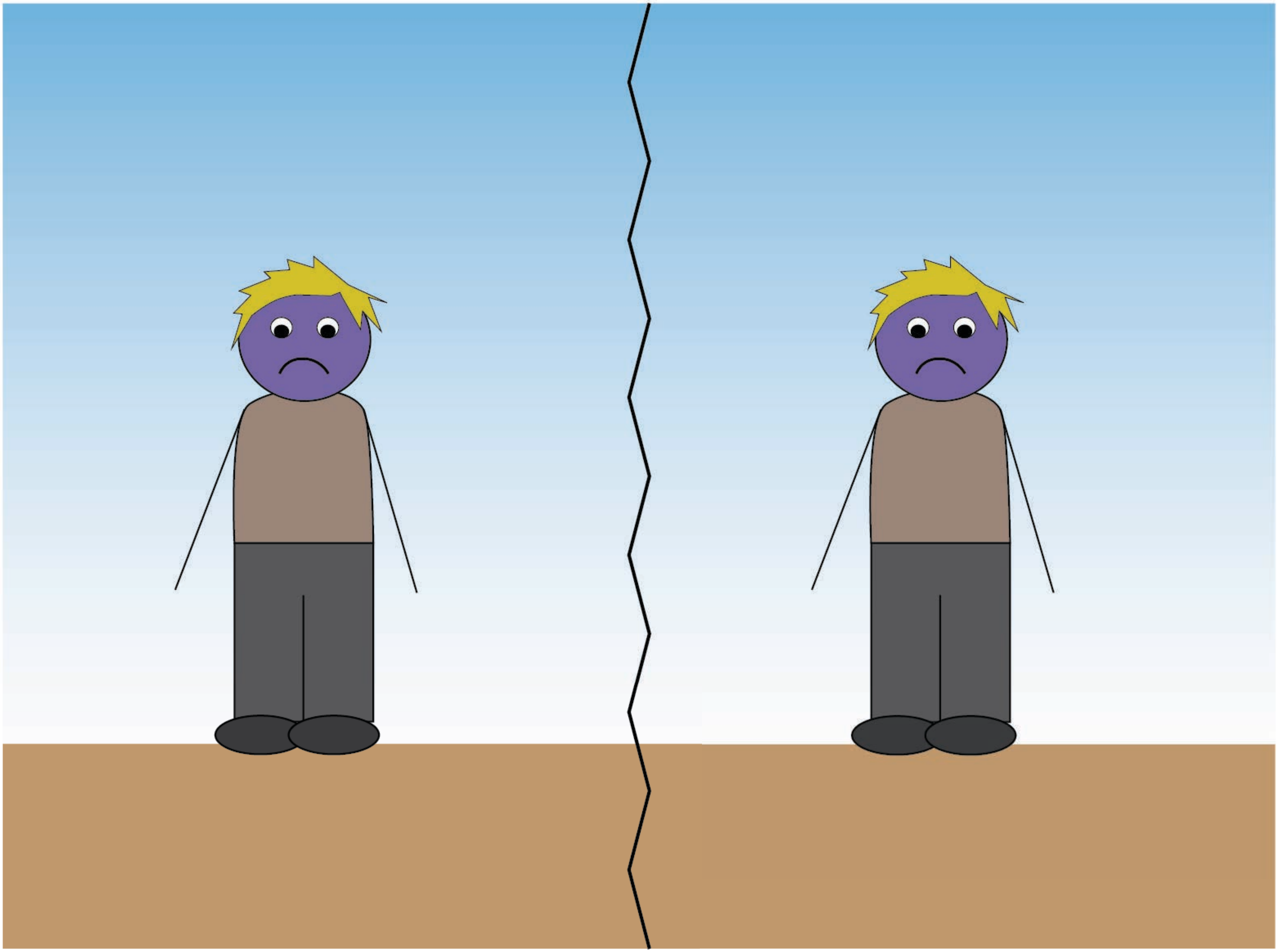
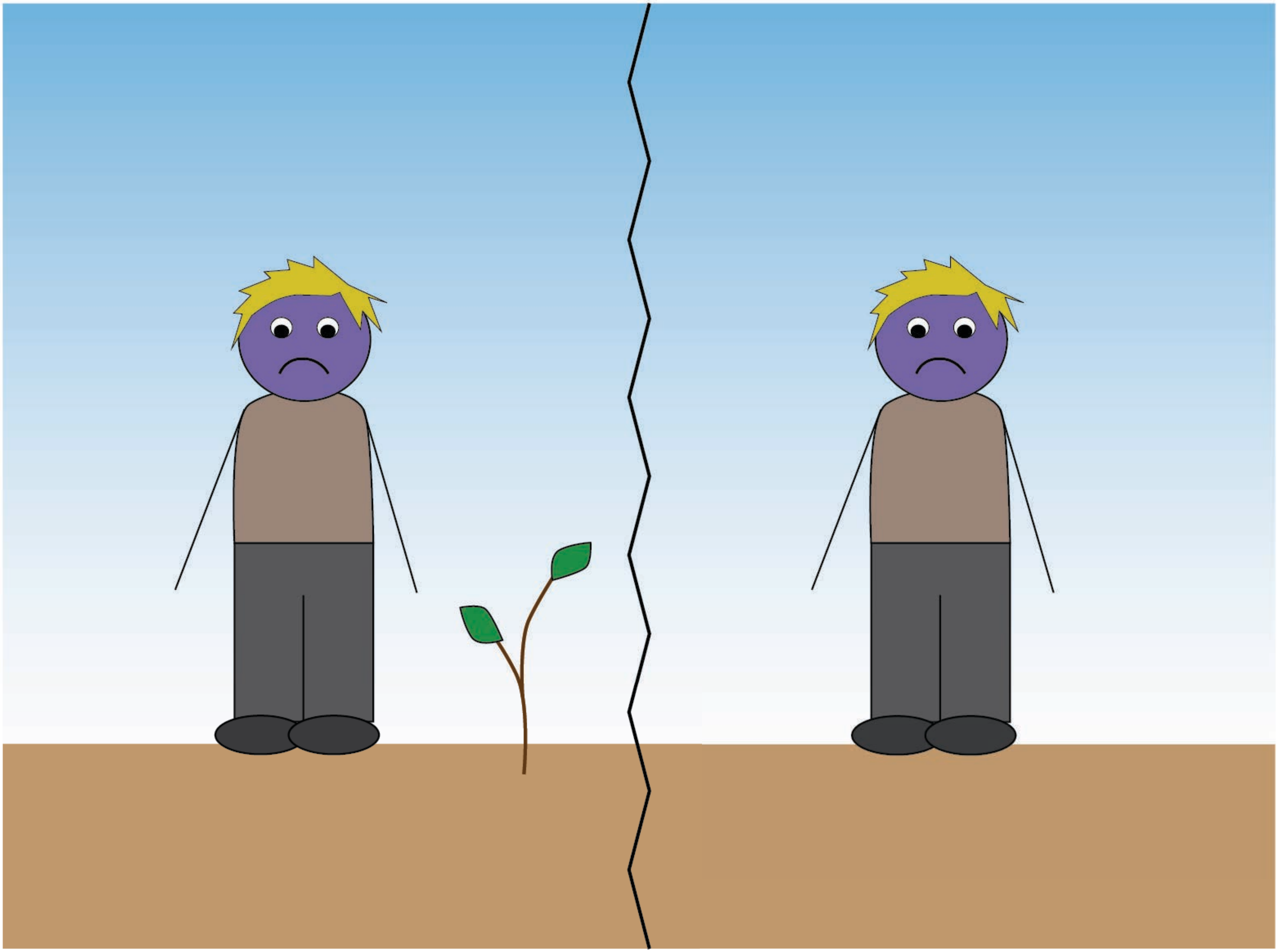
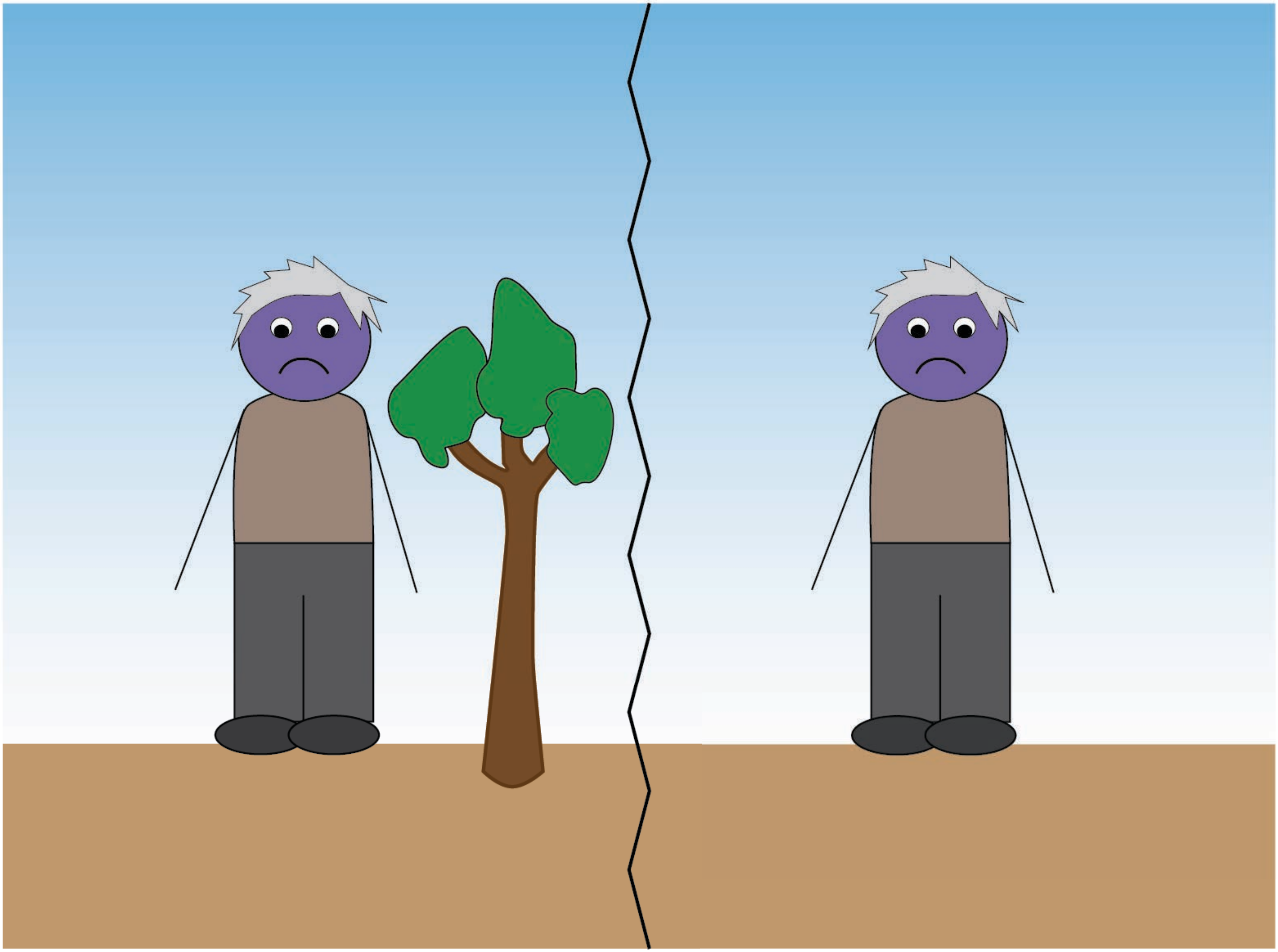
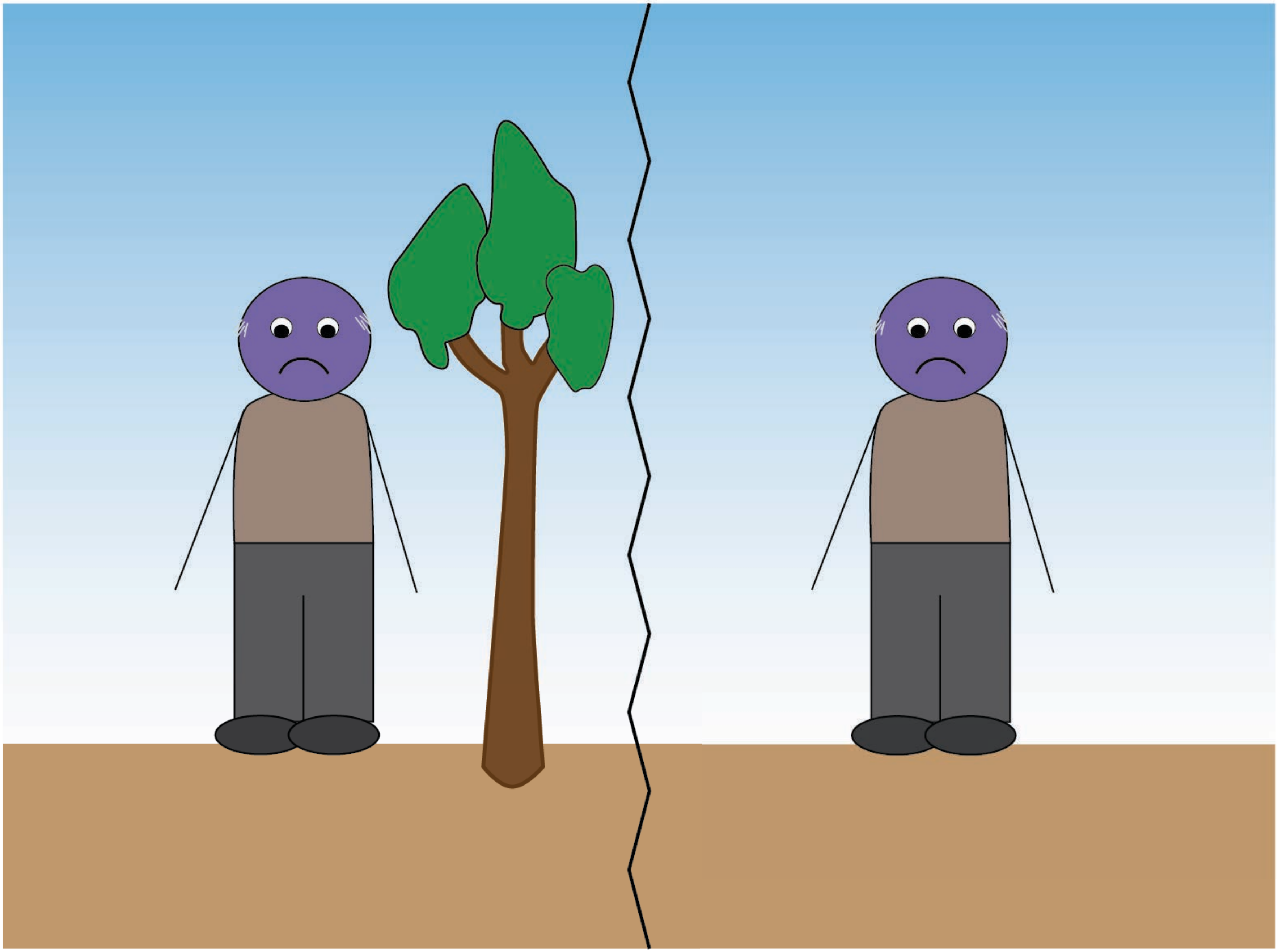
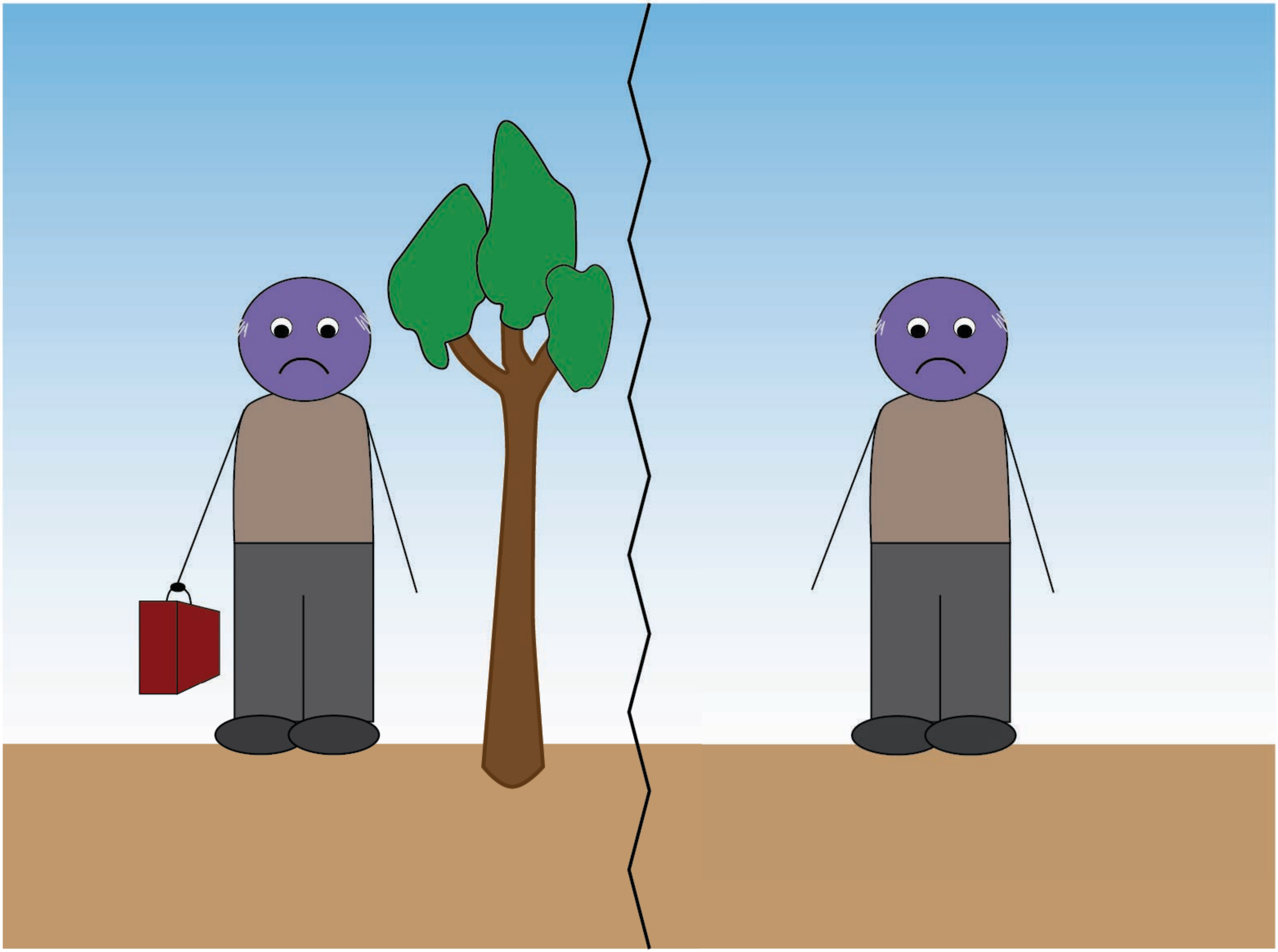
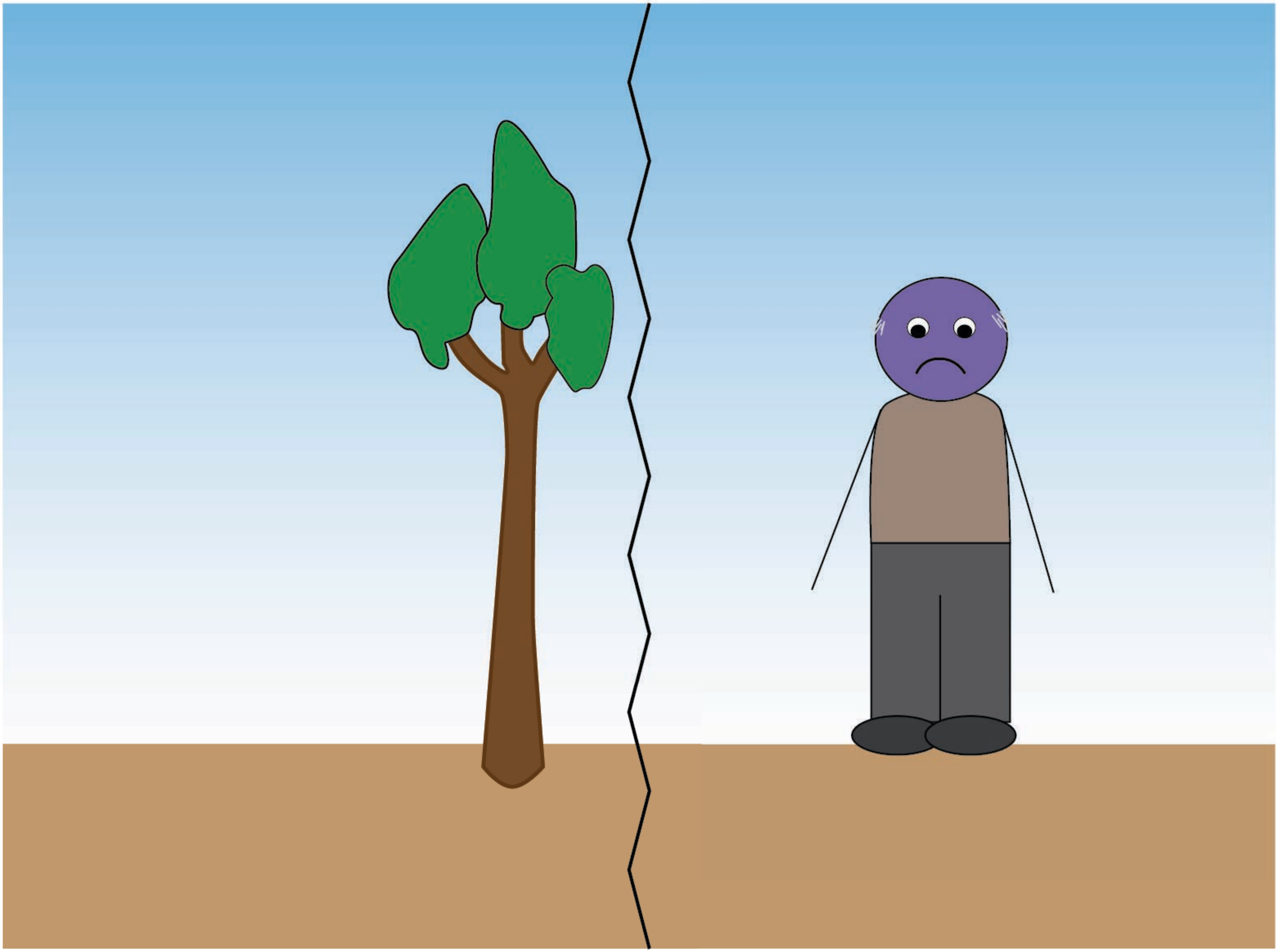


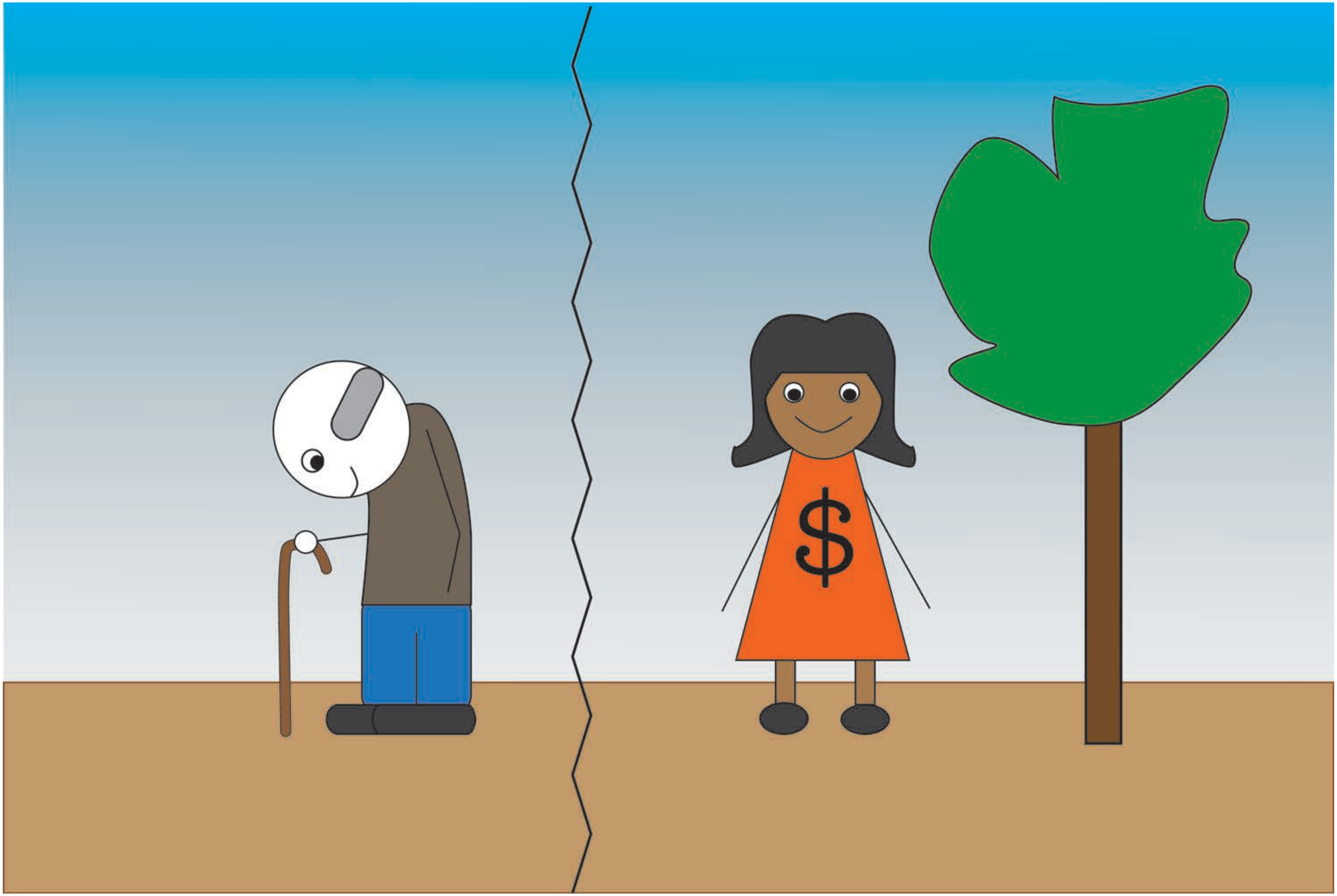


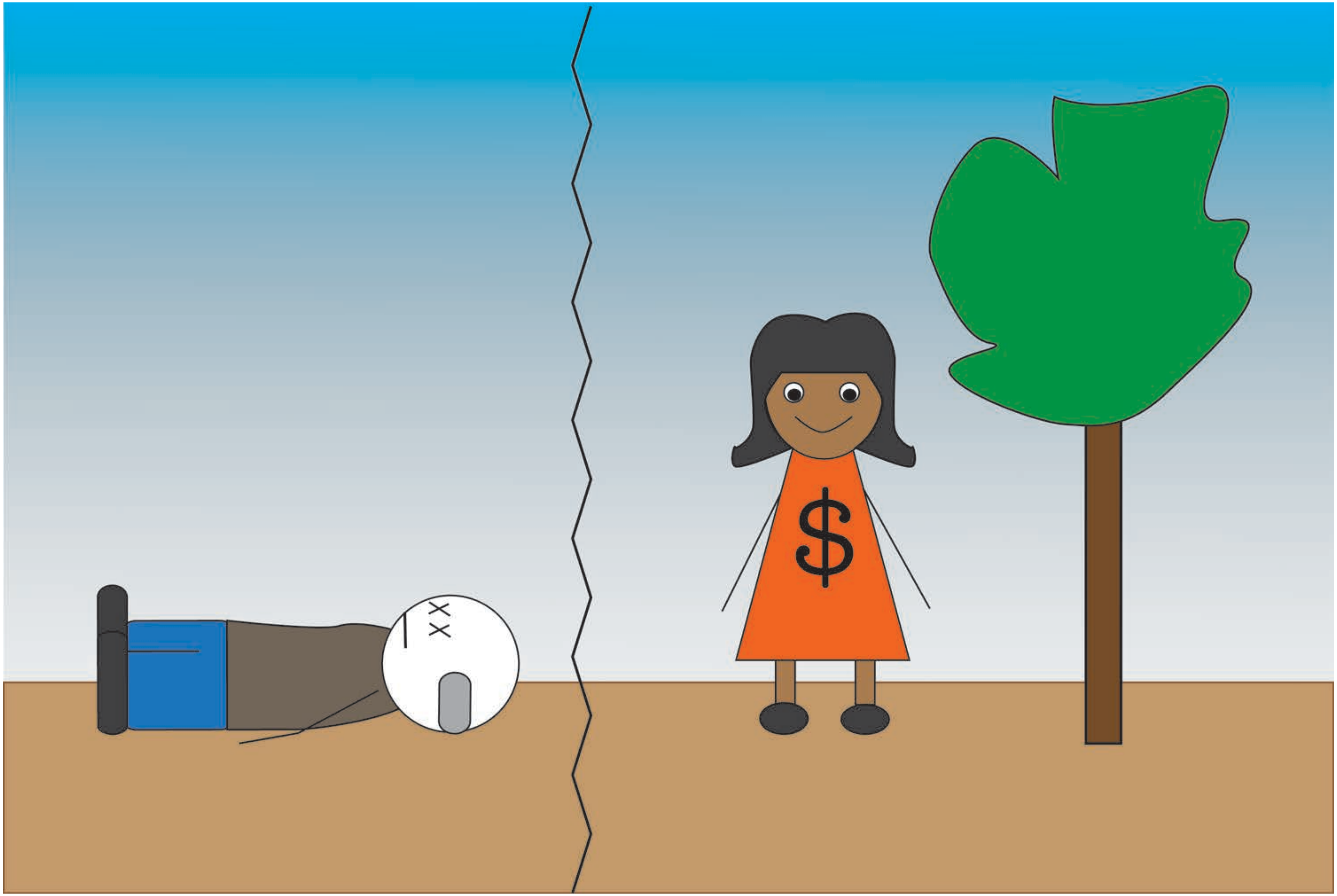


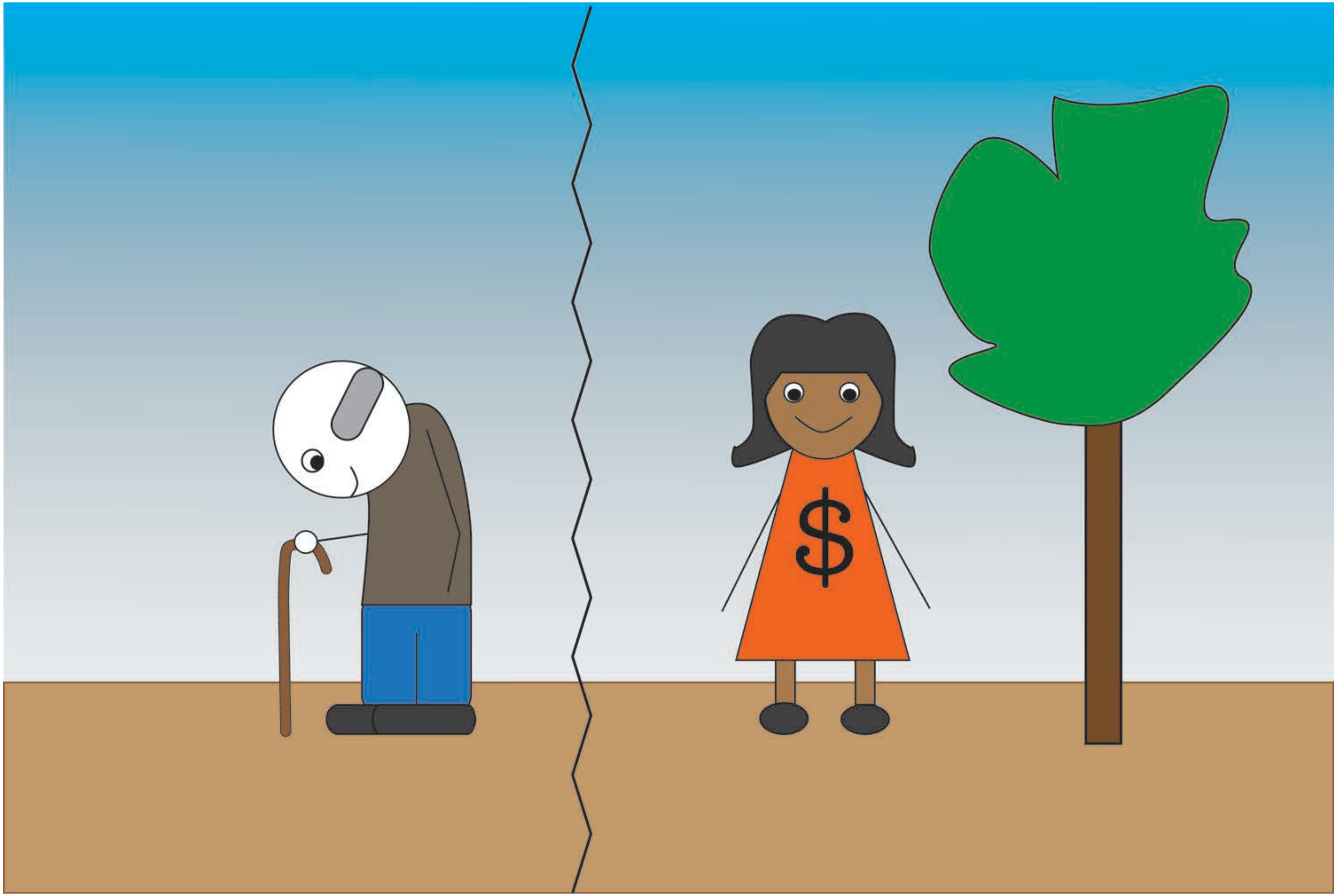


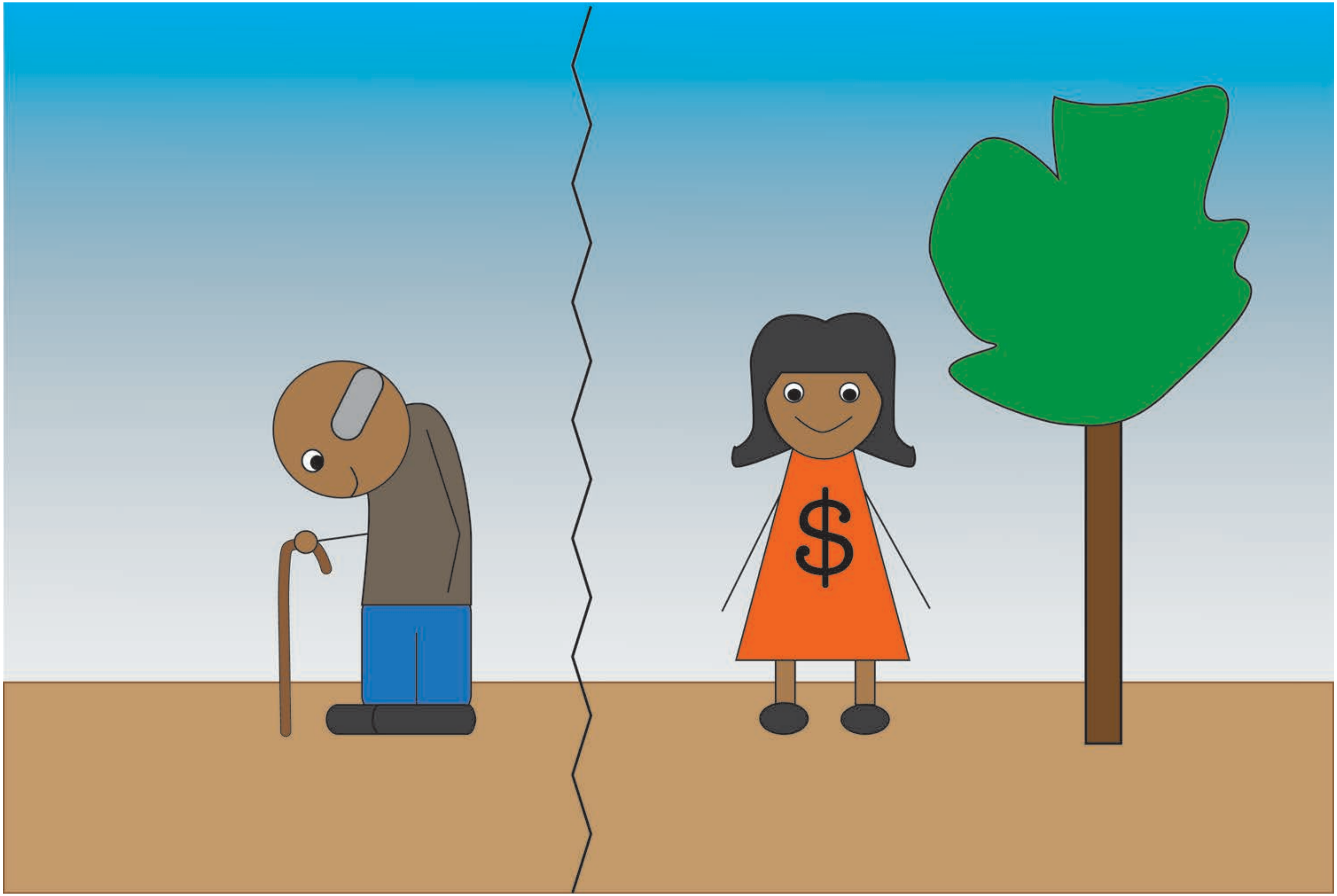


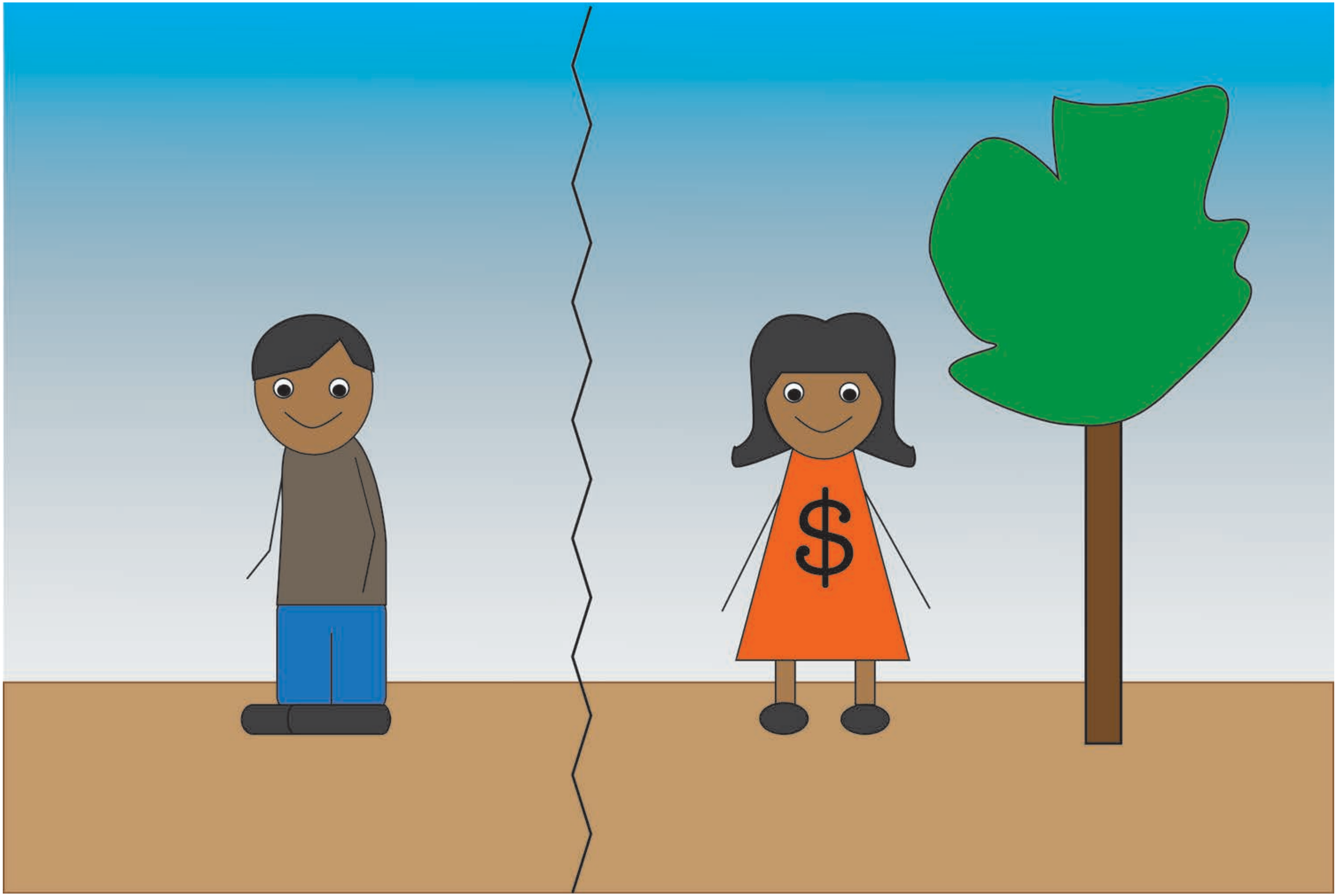


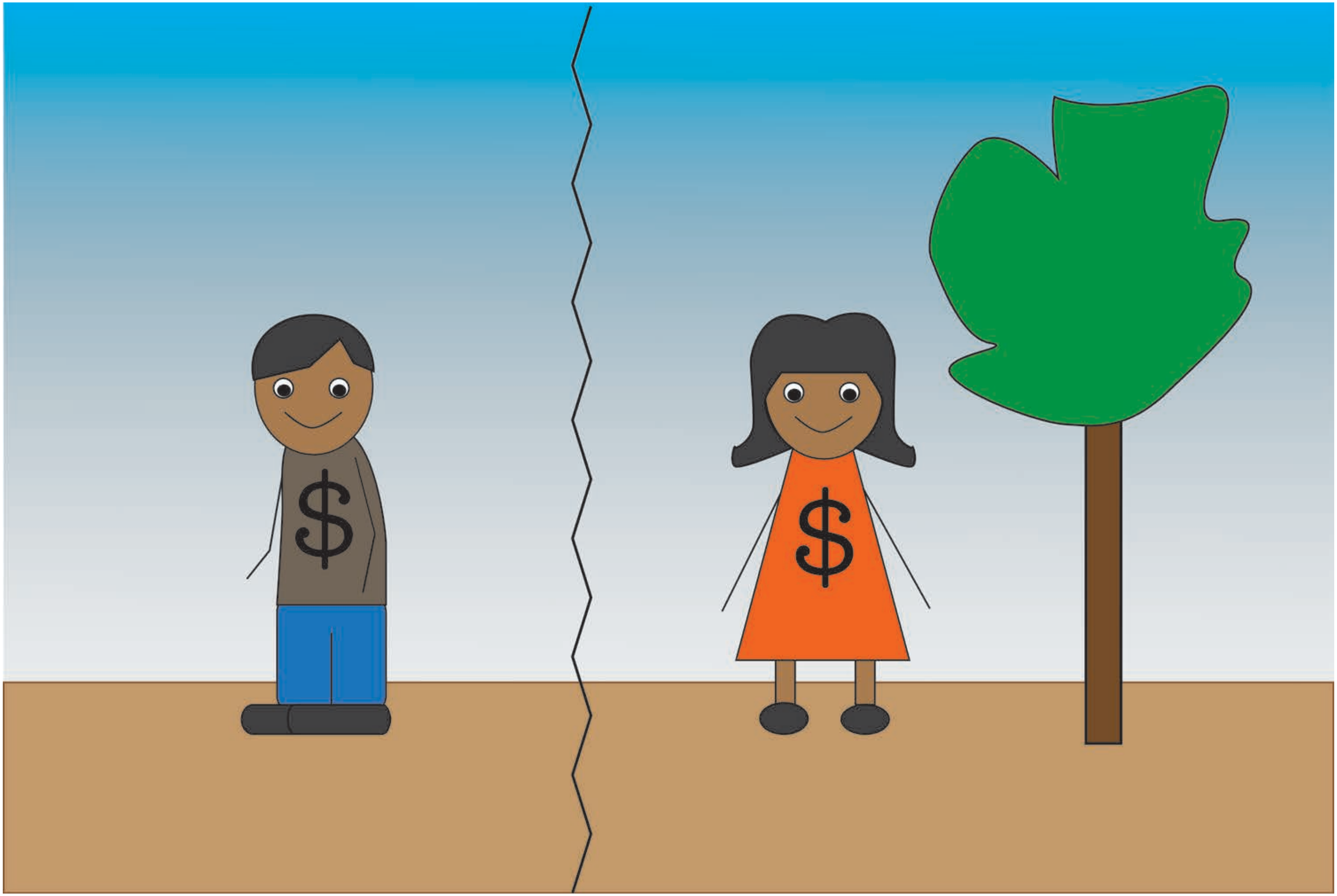


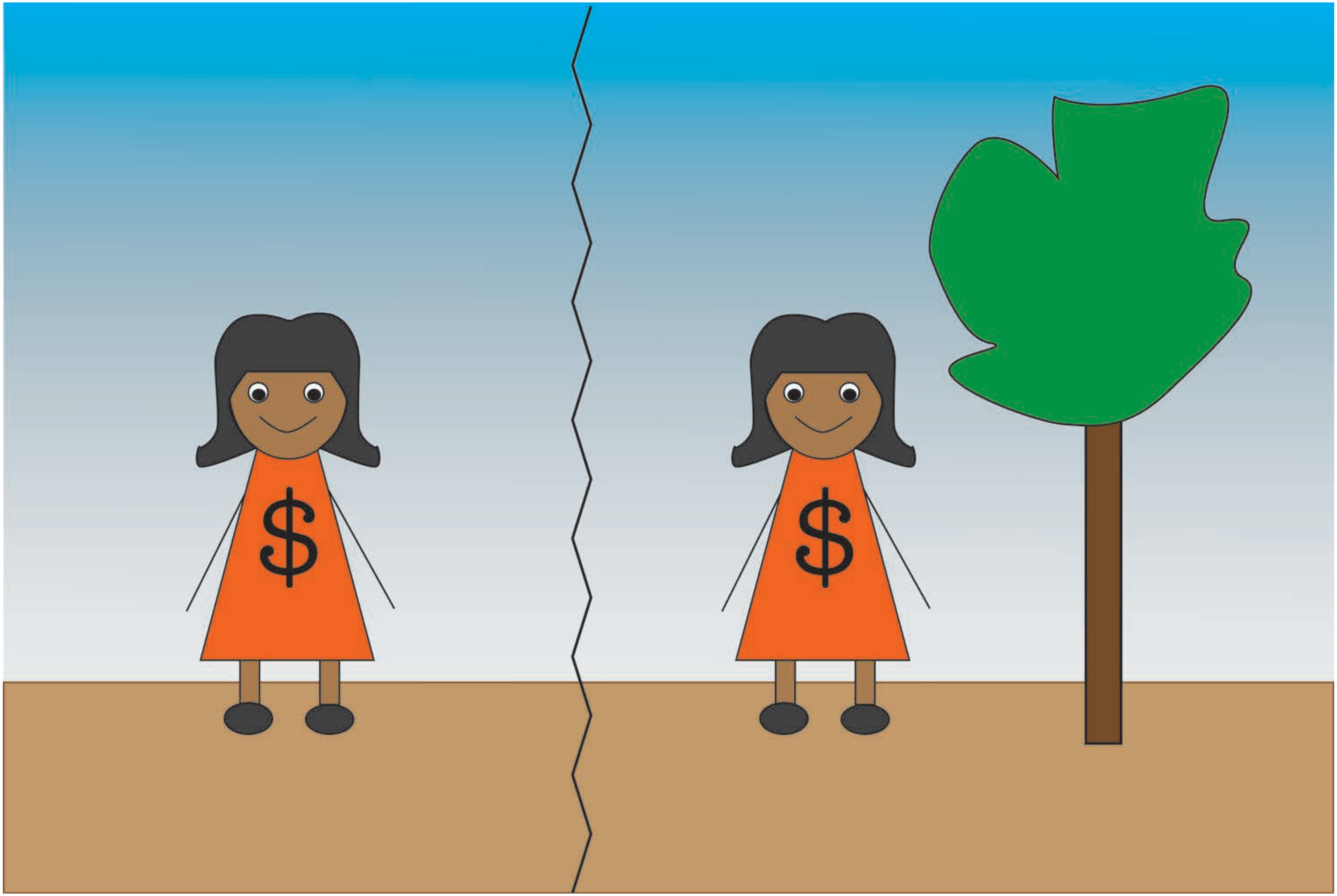


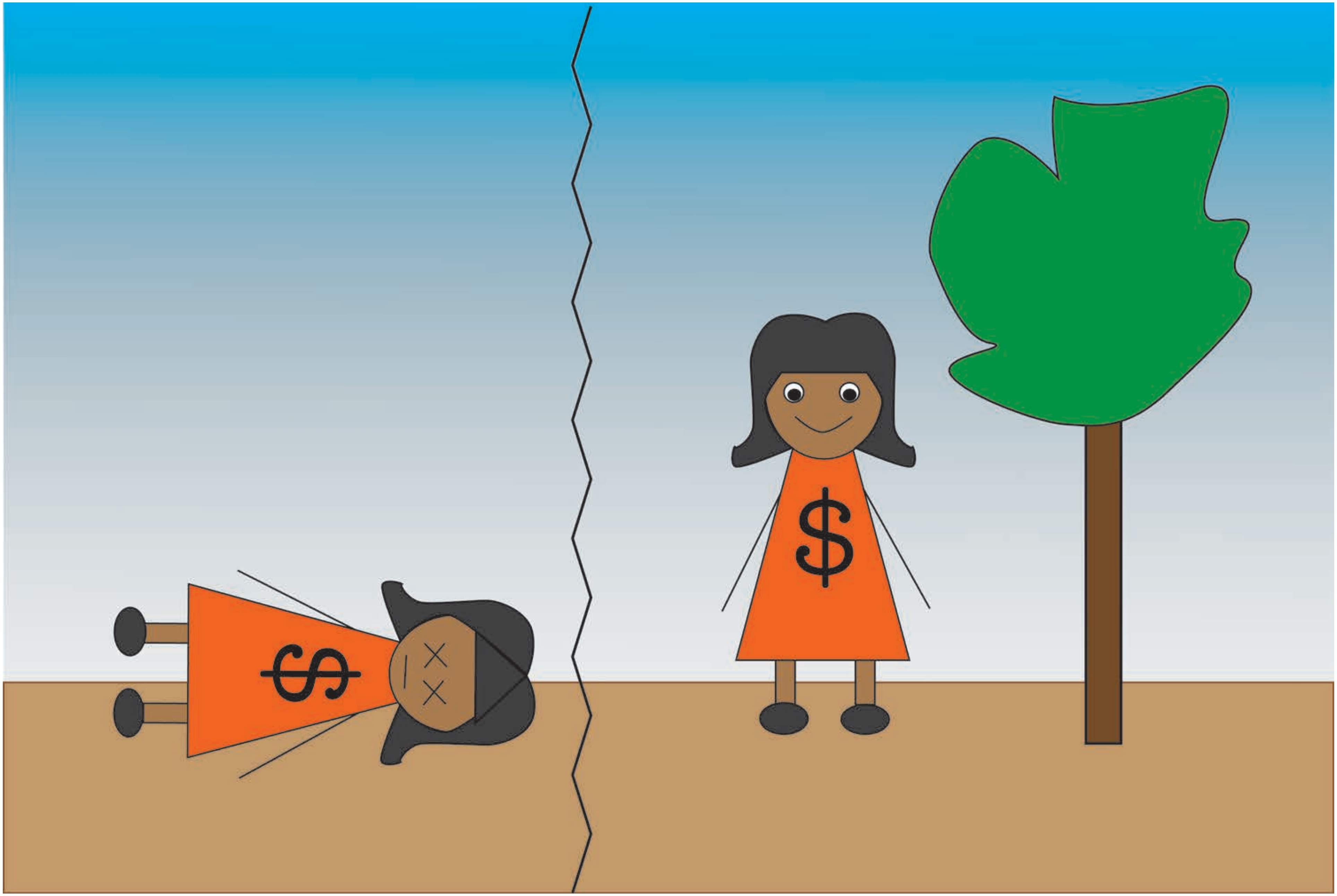


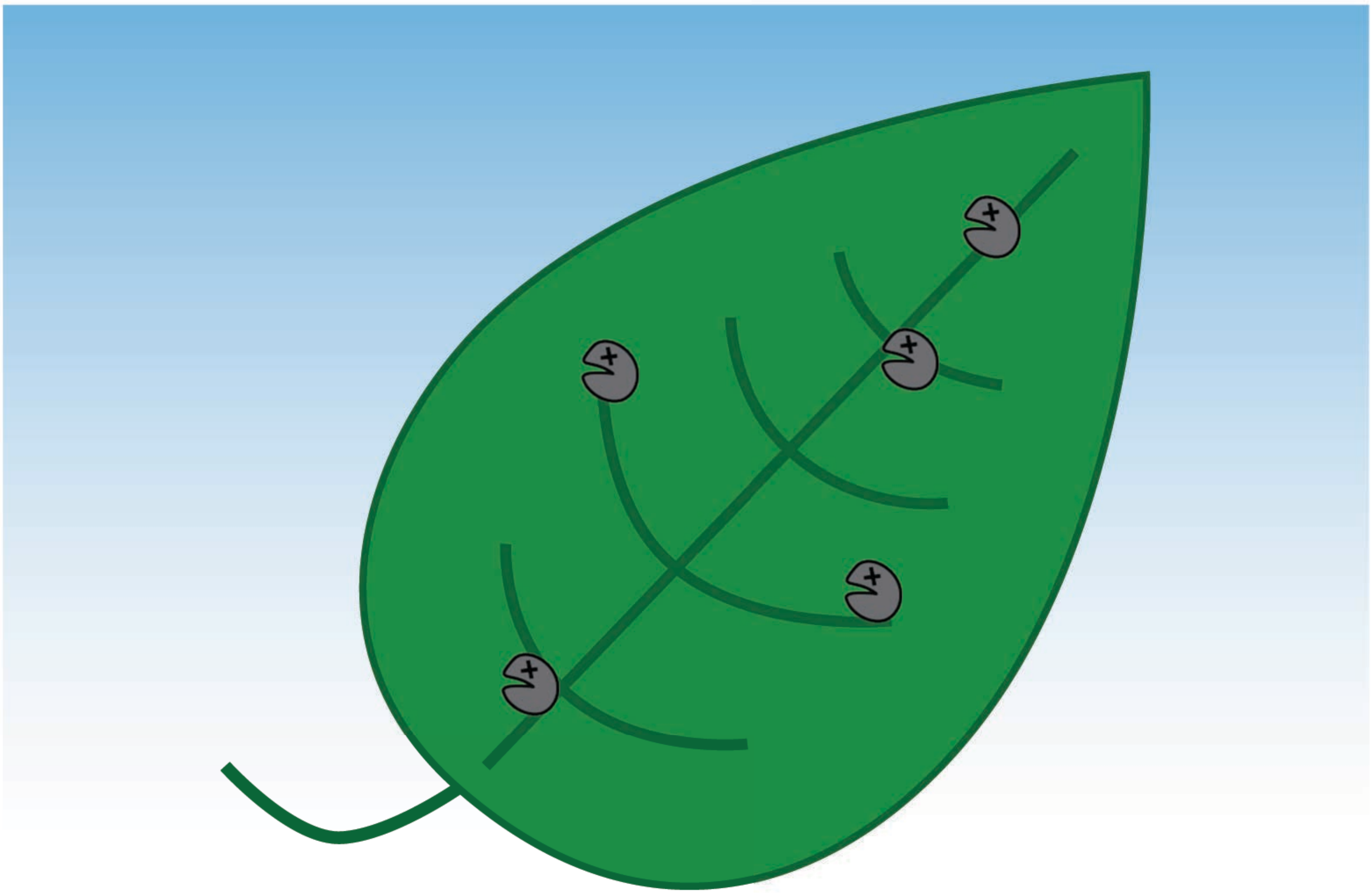


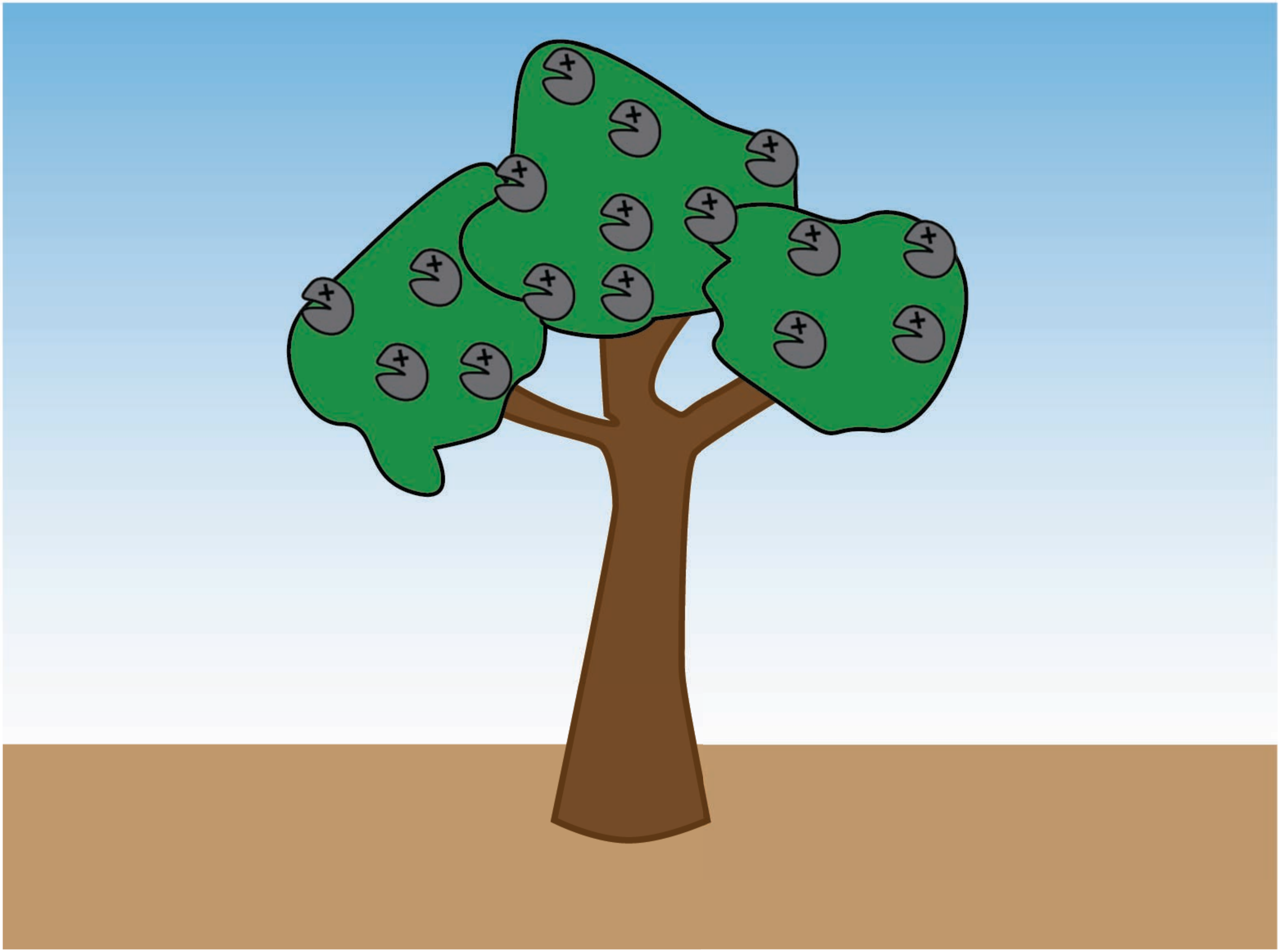


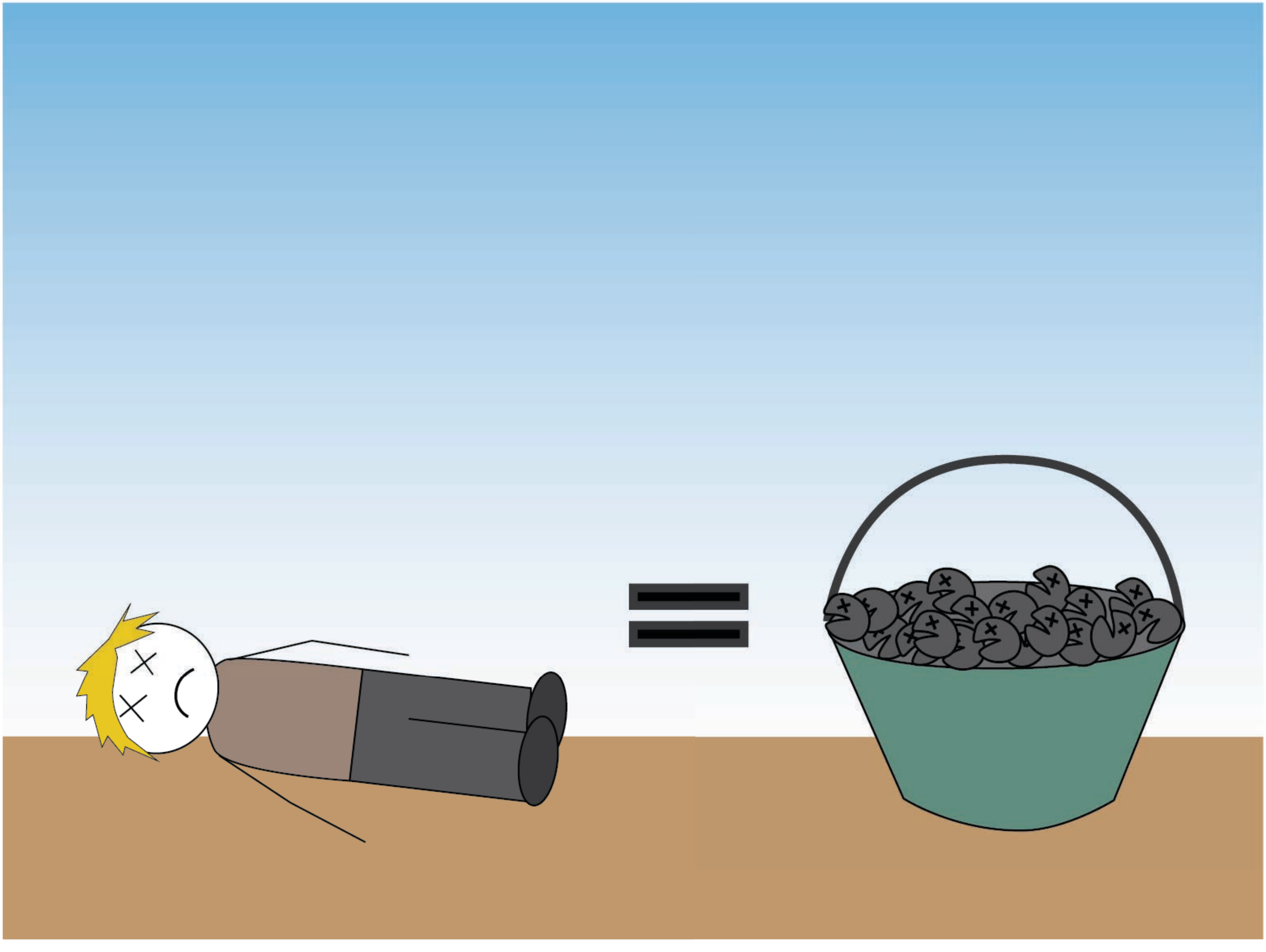


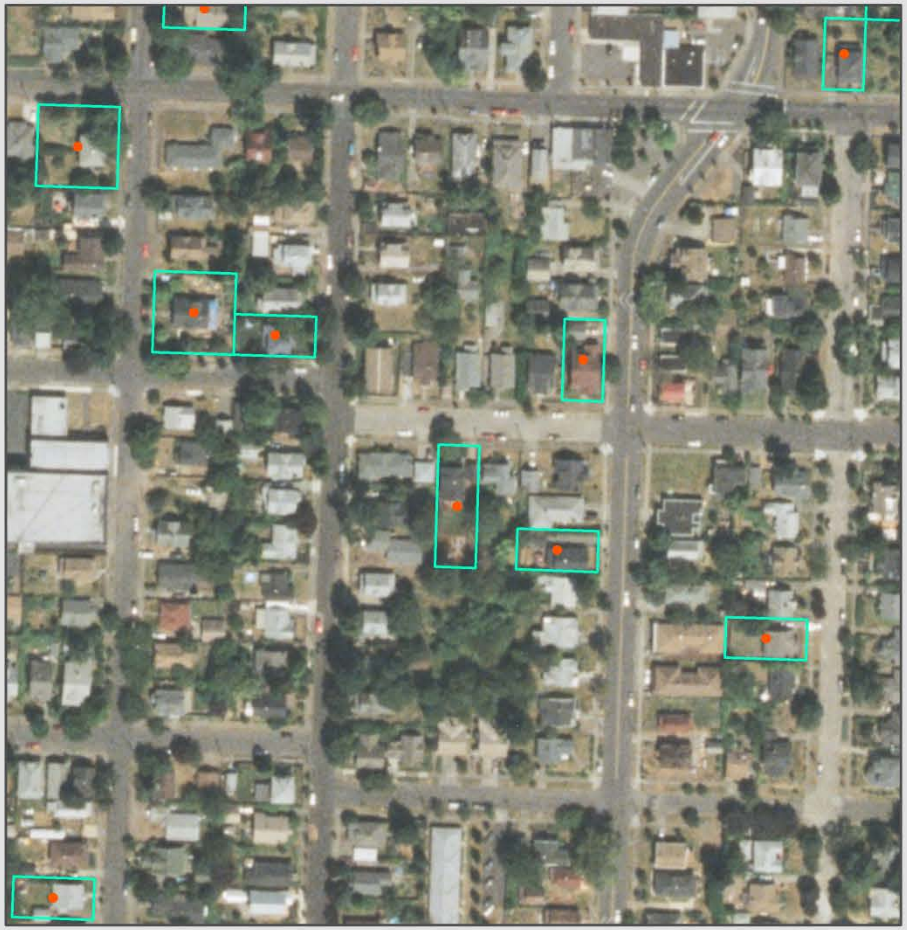




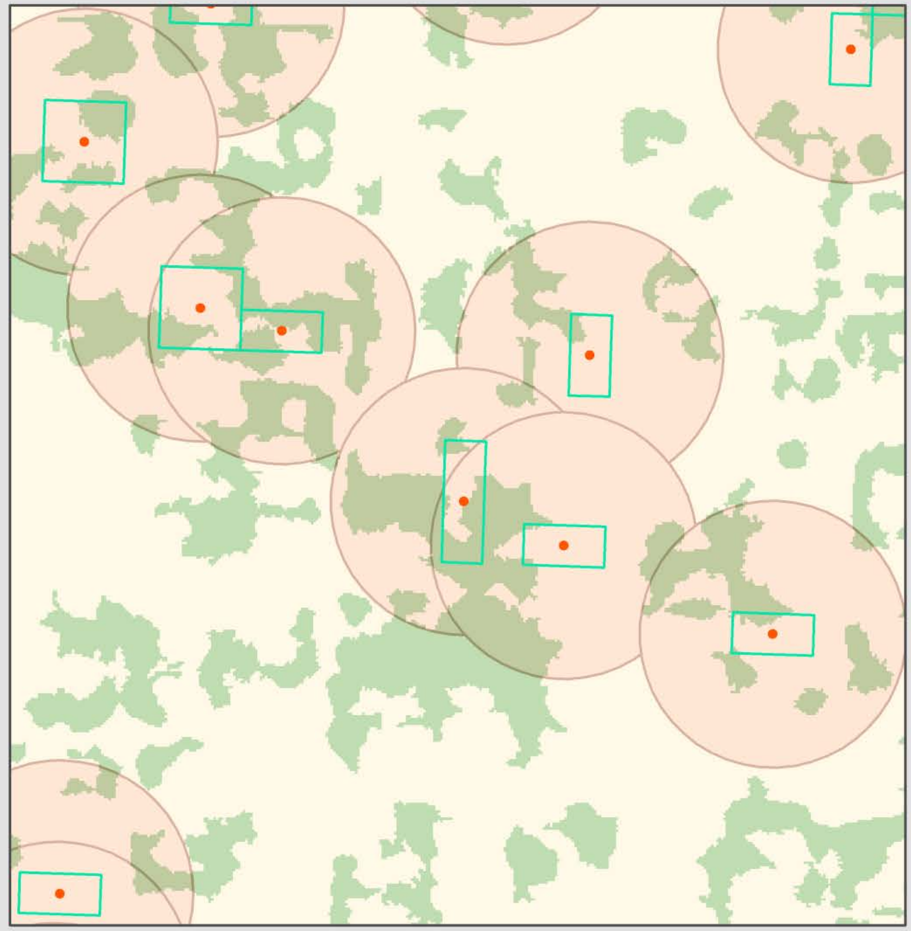








Half meter natural color aerial imagery with taxlot polygons and centroids around which buffers were calulated.



Tree canopy layer extracted from classification of aerial imagery with 50 meter buffers around taxlot polygon centroids. Green is tree canopy and tan is non-canopy.

150

Meters

Source: Portland Metro Regional Government Regional Land Information System (RLIS), City of Portland Bureau of Planning and Sustainability.

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Full length article

Green space, health inequality and pregnancy

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ABSTRACT

Green spaces have been suggested to improve physical and mental health and well-being by increasing physical activity, reducing air pollution, noise, and ambient temperature, increasing social contacts and relieving psychophysiological stress. Although these mechanisms also suggest potential beneficial effects of green spaces on pregnancy outcomes, to our knowledge there is no available epidemiological evidence on this impact. We investigated the effects of surrounding greenness and proximity to major green spaces on birth weight and gestational age at delivery and described the effect of socioeconomic position (SEP) on these relationships. This study was based on a cohort of births (N= 8246) that occurred in a major university hospital in Barcelona, Spain, during 2001–2005. We determined surrounding greenness from satellite retrievals as the average of Normalized Difference Vegetation Index (NDVI) in a buffer of 100 m around each maternal place of residence. To address proximity to major green spaces, a binary variable was used to indicate whether maternal residential address is situated within a buffer of 500 m from boundaries of a major green space. For each indicator of green exposure, linear regression models were constructed to estimate change in outcomes adjusted for relevant covariates including individual and area level SEP. None of the indicators of green exposure was associated with birth weight and gestational age. After assessing effect modification based on the level of maternal education, we detected an increase in birth weight (grams) among the lowest education level group (N= 164) who had higher surrounding NDVI (Regression coefficient (95% confidence interval (CI) of 436.3 (43.1, 829.5)) or lived close to a major green space (Regression coefficient (95% CI)) of 189.8 (23.9, 355.7)). Our findings suggest a beneficial effect of exposure to green spaces on birth weight only in the lowest SEP group.

1. Introduction

About half of the global population now lives in cities and it is estimated that by 2030 three of every five persons will live in urban areas (Fuller and Gaston, 2009; Smith and Guarnizo, 2009). Urbanization has led more people to live in less green environments (Fuller and Gaston, 2009; Tzoulas et al., 2007). Green spaces have been suggested to improve both perceived and objective physical and mental health and well-being (Bowler et al., 2010), reduce the income-related inequality in health (Mitchell and Popham, 2008), and be a major component of sustainability of urban environments, particularly in the context of predicted future changes in climate (Marmot, 2010).

Although the underlying mechanisms of the effects of green spaces on health are not fully understood, increasing physical activity, enhancing social contacts, improving psychophysiological stress and depression, reducing noise and air pollution levels, and regulating microclimates (i.e. moderating ambient temperature and urban heat island effects) have been suggested to be involved (Bowler et al., 2010; Gill et al., 2007; Greenspace Scotland, 2008; Health Council of The Netherlands, 2004; Lee and Maheswaran, 2011; Maas et al., 2009a, 2009b; Nowak et al., 2006; Whitford et al., 2001). Through these mechanisms, green spaces would also be able to affect pregnancy outcomes. For example, green spaces increase physical activity and moderate physical activity during pregnancy is reported to be associated with better maternal mental health (Poudevigne and Oconnor, 2006) and lower risk of adverse pregnancy outcomes like low birth weight and pre-eclampsia (Both et al., 2010; Hegaard et al., 2007). Maternal

Abbreviations: ETM+, Landsat Enhanced Thematic Mapper Plus; NDVI, Normalized Difference Vegetation Index; SEP, Socioeconomic position.

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Short Report

Green spaces and pregnancy outcomes in Southern California

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ABSTRACT

Little is known about the impacts of green spaces on pregnancy outcomes. The relationship between green space exposure and preeclampsia has never been studied. We used a hospital-based perinatal database including more than 80,000 births to study the relationships between greenness exposure and three pregnancy outcomes: birth weight in term born infants, preterm deliveries and preeclampsia. Greenness was characterized using the normalized difference vegetation index (NDVI) within circular buffers surrounding maternal homes. Analyses were conducted using generalized estimating equations, adjusted for potential confounders. We observed an increase in birth weight in term born infants and a reduced risk of preterm births associated with an increase in NDVI. No significant association was observed between greenness and preeclampsia. This study provides modest support for beneficial effects of greenness exposure on pregnancy outcomes and calls for confirmation in other study settings.

1. Introduction

In a context of rapid urbanization at the global scale, there is growing interest in the relationships between green spaces and health (Bowler et al., 2010; Lee and Maheswaran, 2011; Maas et al., 2009). Greenness exposure has been associated with reductions in risks of various health outcomes, including self-perceived health (Maas et al., 2006; Mitchell and Popham, 2007), blood pressure (Agyemang et al., 2007) and mortality (Villeneuve et al., 2012). The causal nature of these associations is not established to date (Bowler et al., 2010; Lee and Maheswaran, 2011) and the biological mechanisms potentially in play are not clear, but possible pathways include reduction of exposure to noise, air pollution (Dadvand et al., 2012b) and urban heat (Jenerette et al., 2011), as well as stress relief (Fan et al., 2011; van den Berg et al., 2010). Such an array of modifications might also be beneficial to pregnancy outcomes.

So far, the relationships between greenness and pregnancy outcomes have been investigated in only three studies (Dadvand et al., 2012a, 2012c; Donovan et al., 2011). All reported increases in birth weight associated with exposure to greenness, and no association with the length of gestation (Dadvand et al., 2012a; 2012c; Donovan et al., 2011). These pioneering findings from studies of 2000 to 8000 subjects need confirmation, ideally from larger studies. No study has examined the relation between greenness and preeclampsia so far, although exposure to green spaces has been associated with decreases in blood pressure (Agyemang et al., 2007) and chronic hypertension is a risk factor for preeclampsia (Hutcheon et al., 2011).

This study examines the relation between greenness exposure and three pregnancy outcomes: birth weight, preterm deliveries and preeclampsia.

2. Methods

Neonatal records from 1997 to 2006 were extracted from a perinatal research database constituted by a network of four hospitals located in Los Angeles and Orange counties, in California, United States (Wu et al., 2009). Residential addresses of mothers at delivery were geocoded with a 93% success rate. Subjects missing important covariate information used in previous studies were excluded (12%) (Wu et al., 2009), as were multiple pregnancies (5%), leaving 81,186 subjects for analysis.

The normalized difference vegetation index (NDVI) (Tucker, 1979) was used to characterize greenness exposure (Dadvand et al., 2012c; Villeneuve et al., 2012). NDVI is the ratio of the difference between the near-infrared region and red reflectance to the sum of these two measures, calculated as follows:

$$NDVI = (band\ 4 - band\ 3)/(band\ 4 + band\ 3)$$

where band 4 and band 3 are the surface reflectances acquired by the near infrared and red bands, respectively, of Landsat sensors. We used a set of mostly cloud-free Landsat scenes from the Global Land Survey 2005 (GLS, United States Geological Survey) dataset covering Southern California. The GLS 2005 consists of orthorectified Landsat

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Surrounding greenness and birth weight: Results from the GINIplus and LISAplus birth cohorts in Munich

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ABSTRACT

Aim: We investigated the association between surrounding greenness at the mother's residential address at the time of delivery and birth weight in two German birth cohorts and explored potential underlying hypotheses.
Methods: Complete data on 3203 newborns, recruited in Munich between 1996 and 1999, were available. Surrounding greenness was defined using the mean of the Normalized Difference Vegetation Index, which was derived from Landsat 5 TM satellite images.
Results: An interquartile increase of surrounding greenness in a 500-m buffer was associated with an average birth weight increase of 17.6 g (95% CI=0.5 to 34.6). The effect strengthened after individual adjustment for NO_2, PM2.5, distance to major road and population density. The strongest association was found for mothers with less than 10 years of school education. The results remained robust when additionally adjusted for noise or maternal stress during pregnancy. Neighbourhood green spaces were not associated with birth weight.
Conclusions: Surrounding greenness at the birth address was positively associated with birth weight in two birth cohorts in Munich. The mechanisms driving this association remain unclear and warrant further investigation.

1. Introduction

Positive associations between surrounding greenness and birth outcomes have been observed in three recent studies (Dadvand et al., 2012a, b; Donovan et al., 2011). The underlying mechanisms behind these associations are unclear. It has been hypothesised that higher surrounding greenness may increase physical activity and promote social interaction among pregnant women, as well as reduce their psychological stress and depression. Furthermore, areas with higher surrounding greenness are suspected of having lower air pollution and noise levels and may moderate ambient temperature. If one assumes surrounding greenness is a surrogate from neighbourhood green spaces and these have been used interchangeably in previous studies (Dadvand et al., 2012a, b), these same hypotheses could apply.

We aimed to assess the association between surrounding greenness at the mother's residential address at the time of delivery and the birth weight of newborns. We also explored potential underlying hypotheses for this association. Furthermore, in order to determine whether greenness may be acting as a surrogate for green spaces, we investigated whether neighbourhood green spaces are also associated with birth weight.

2. Materials and methods

2.1. Study population

The analyses were based on data collected within two ongoing German birth cohorts: the "German Infant Study on the Influence

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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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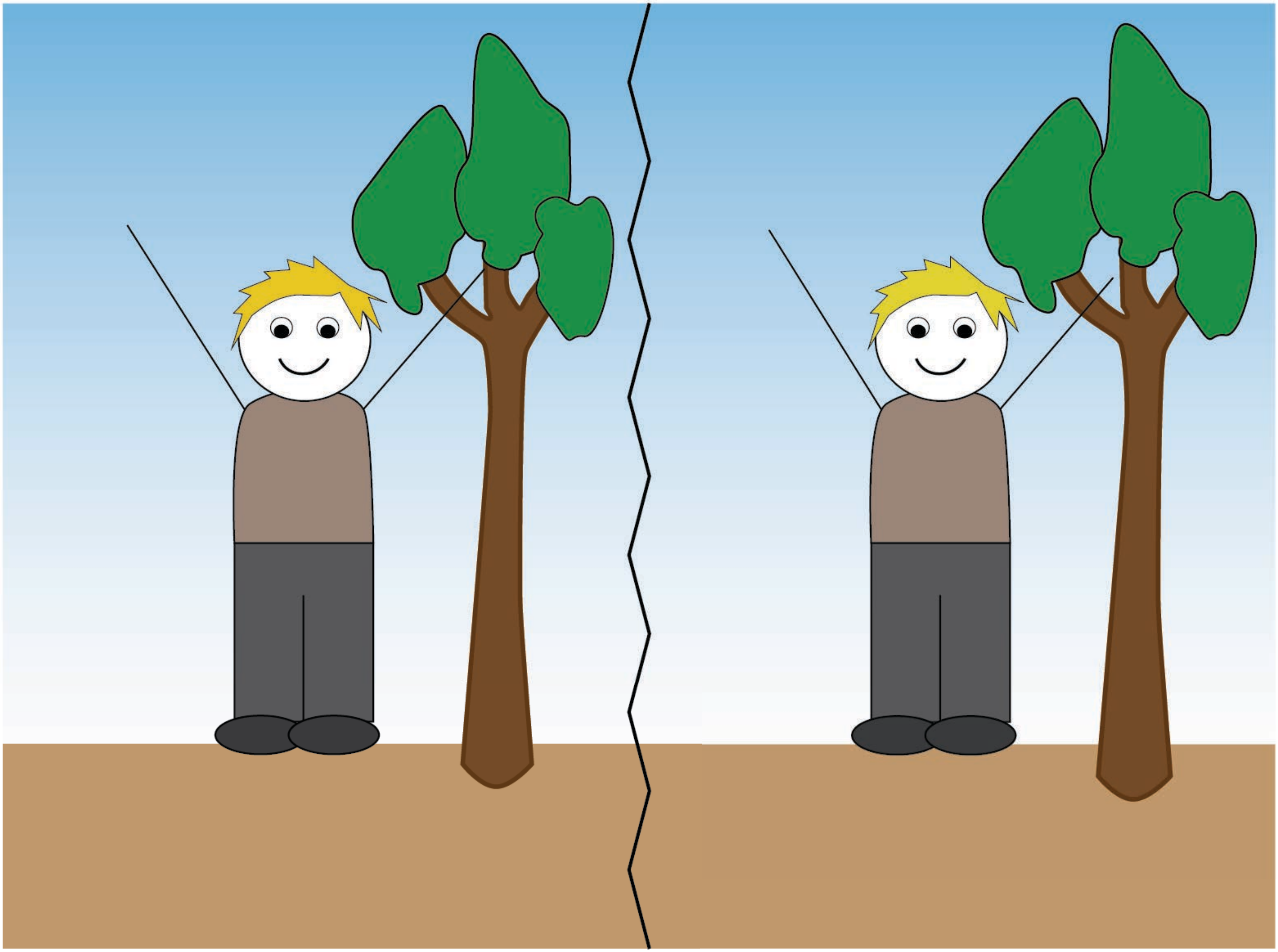

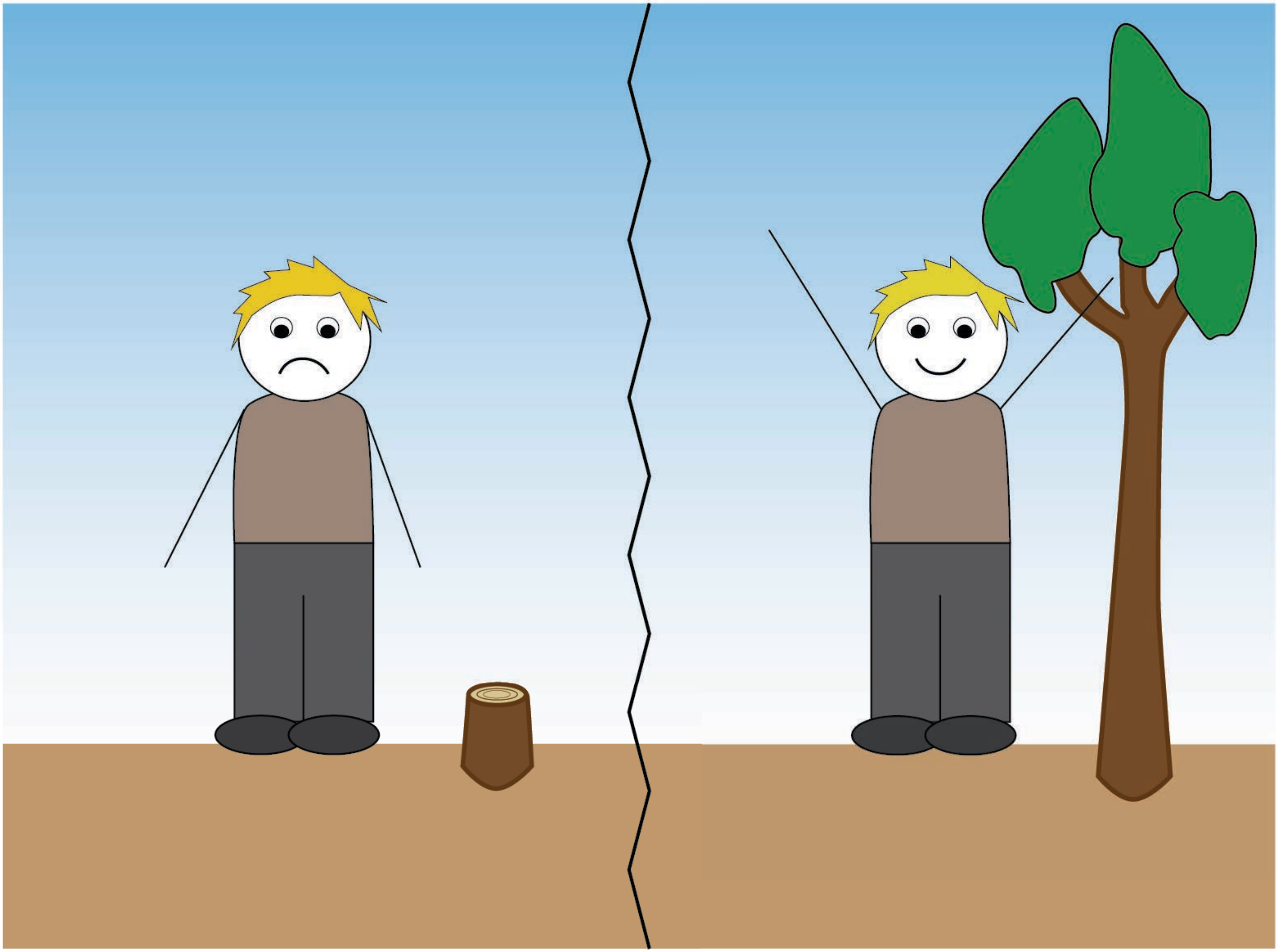


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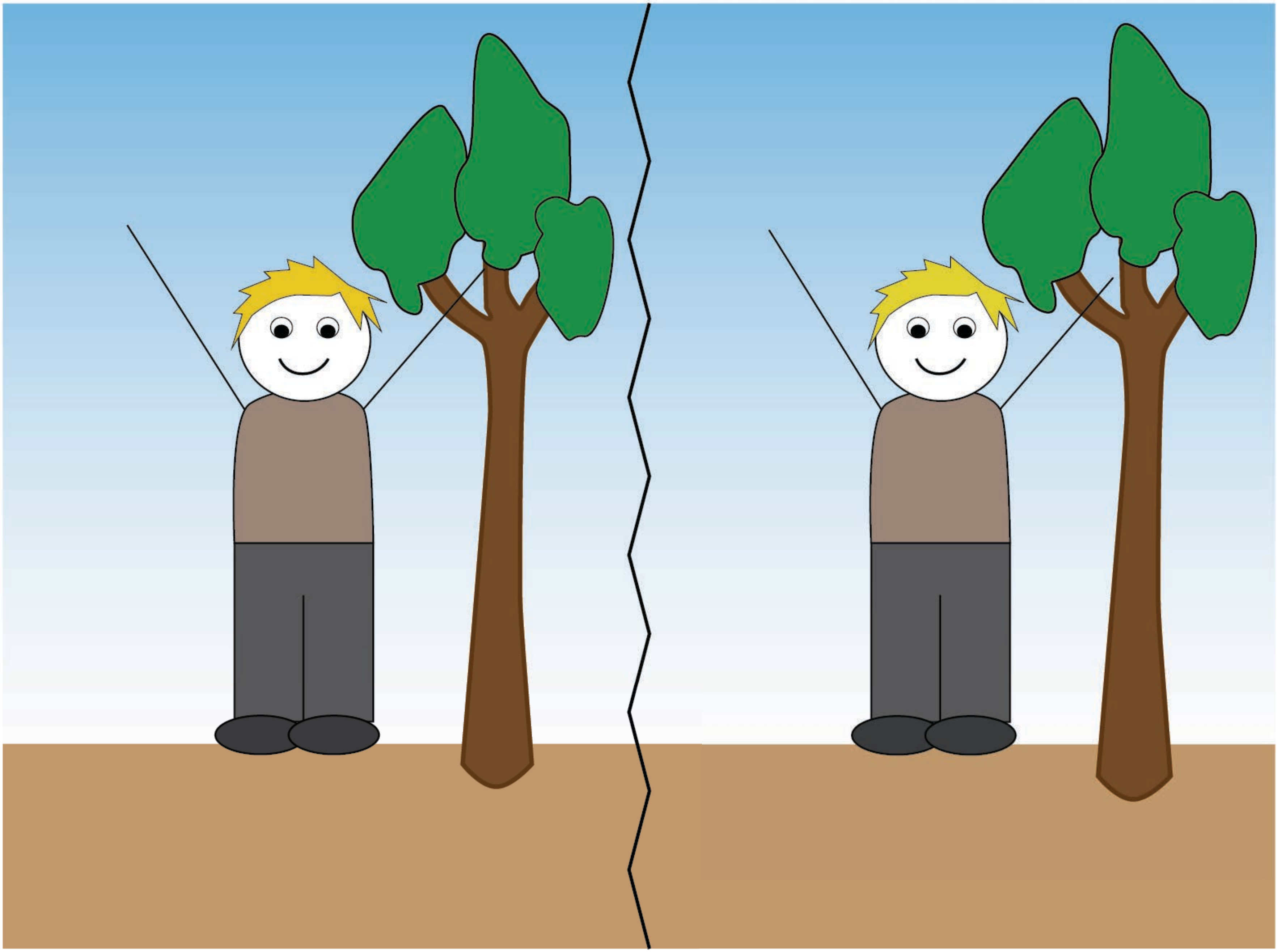
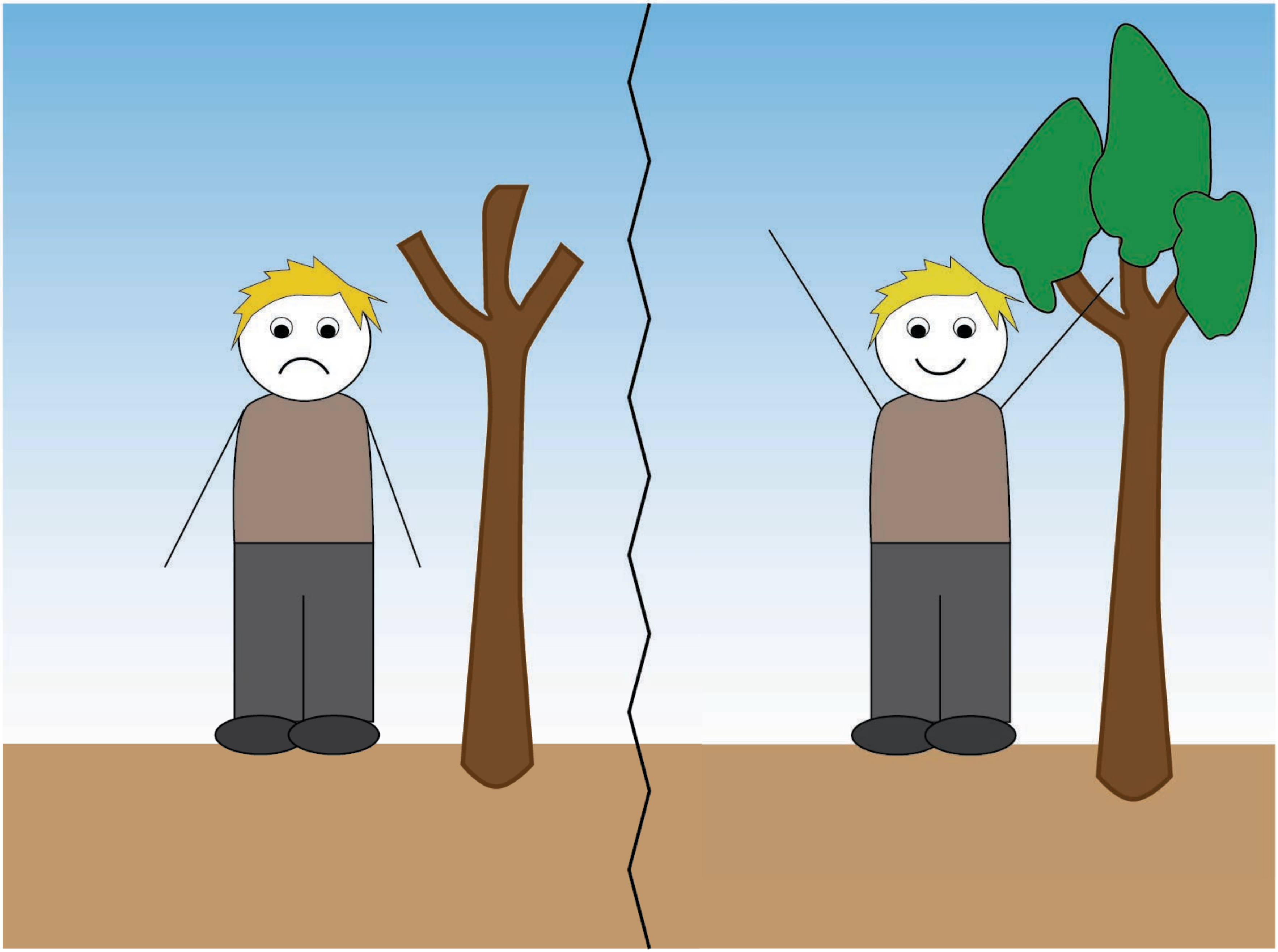
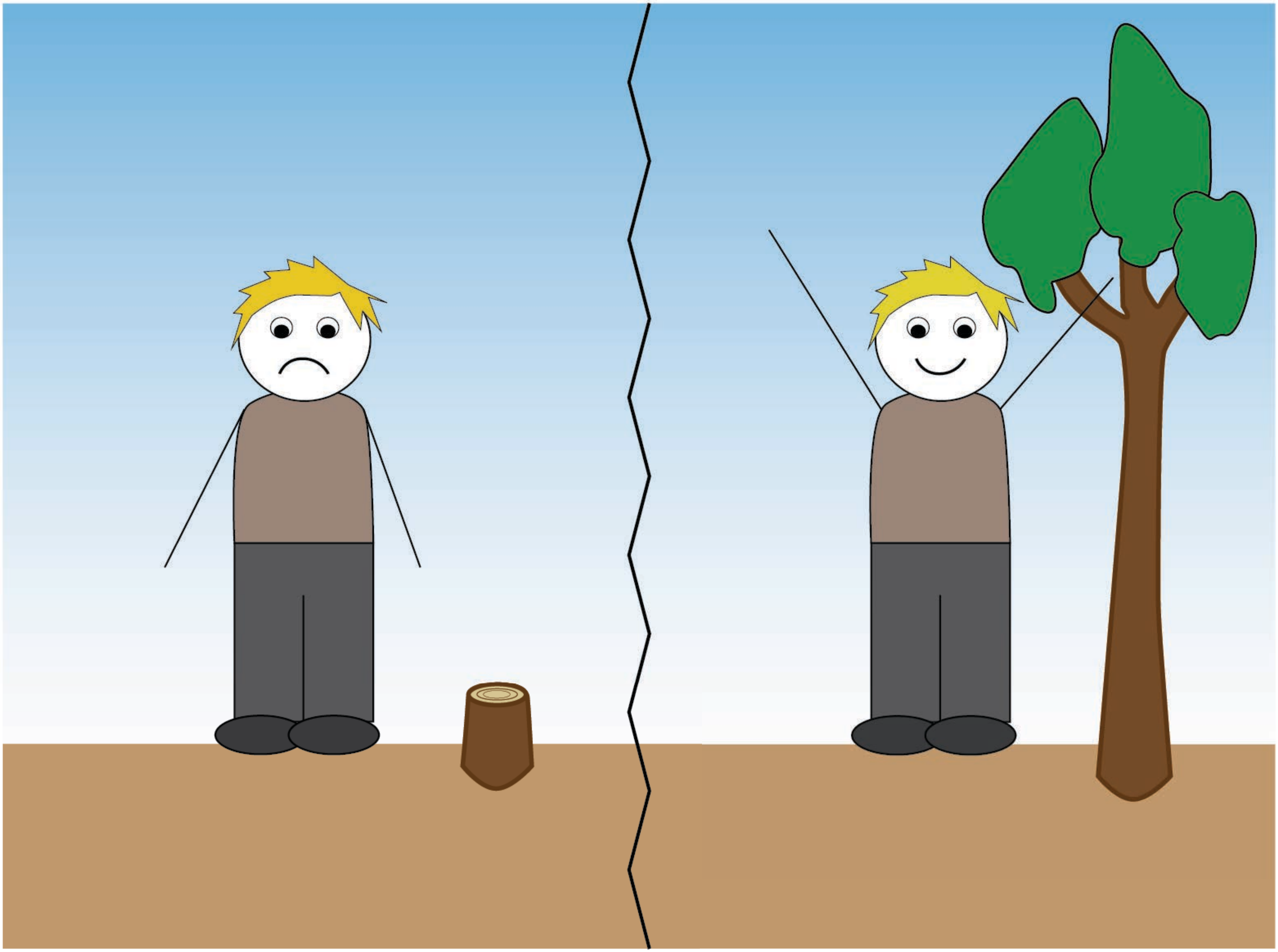
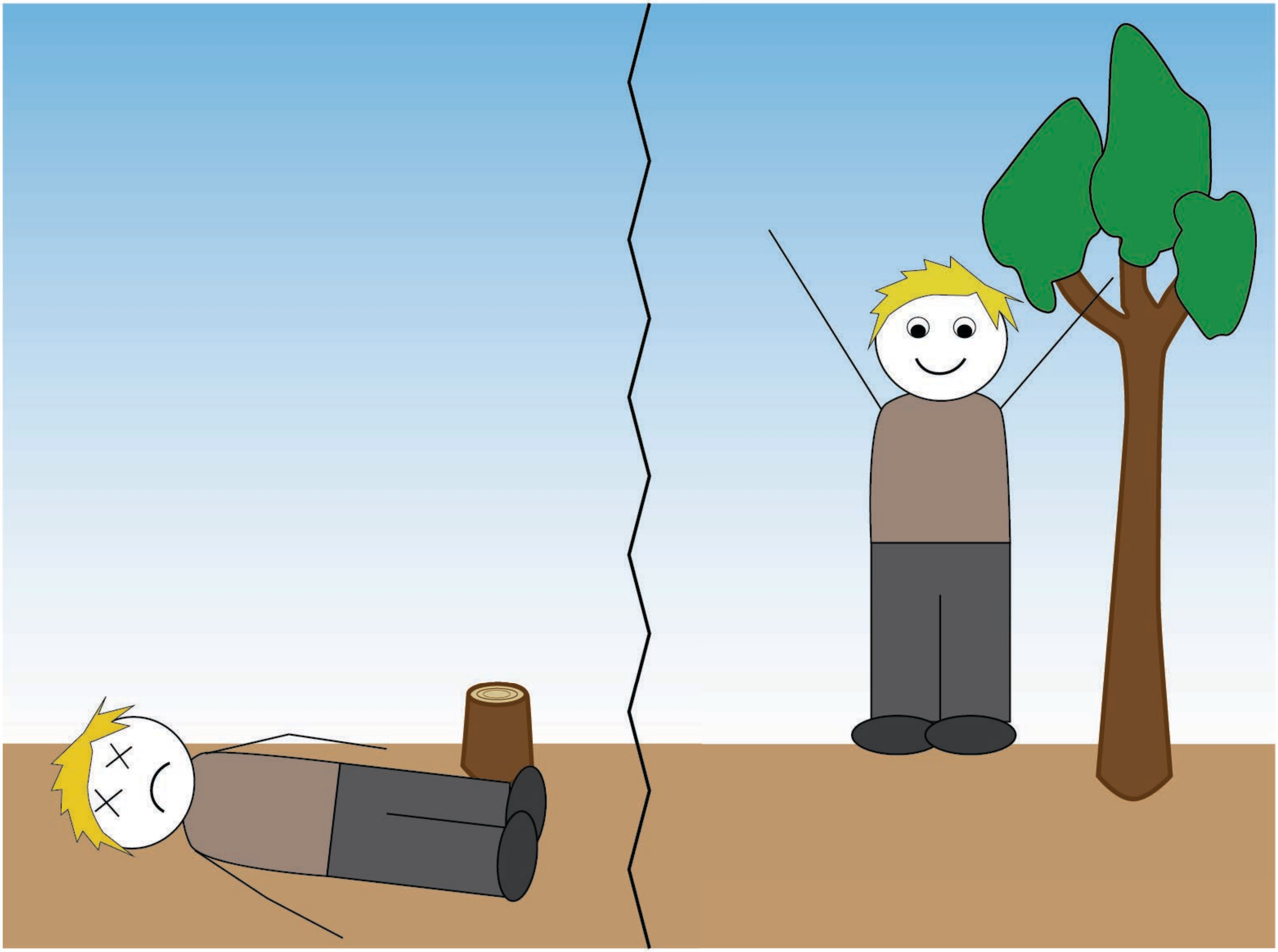
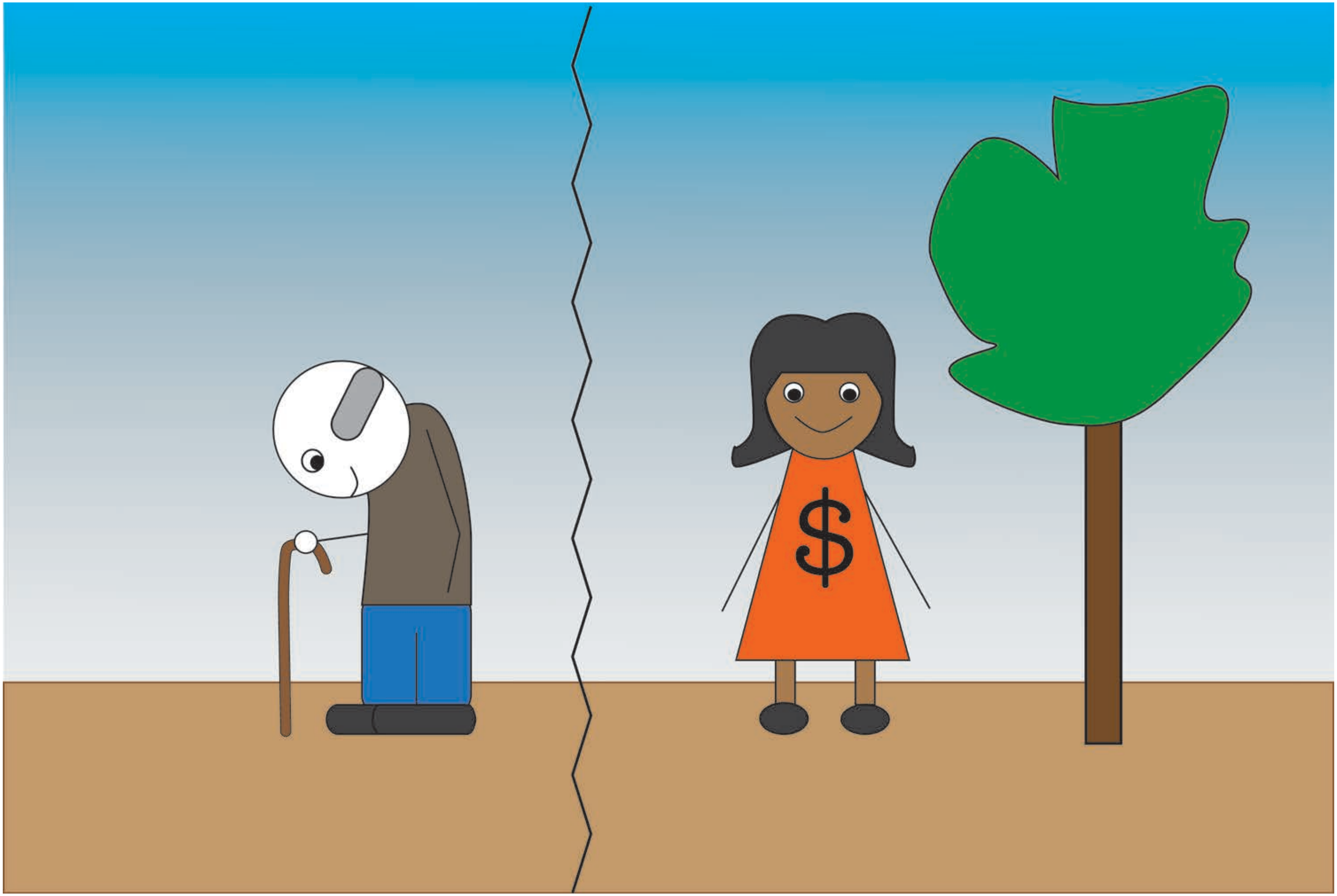
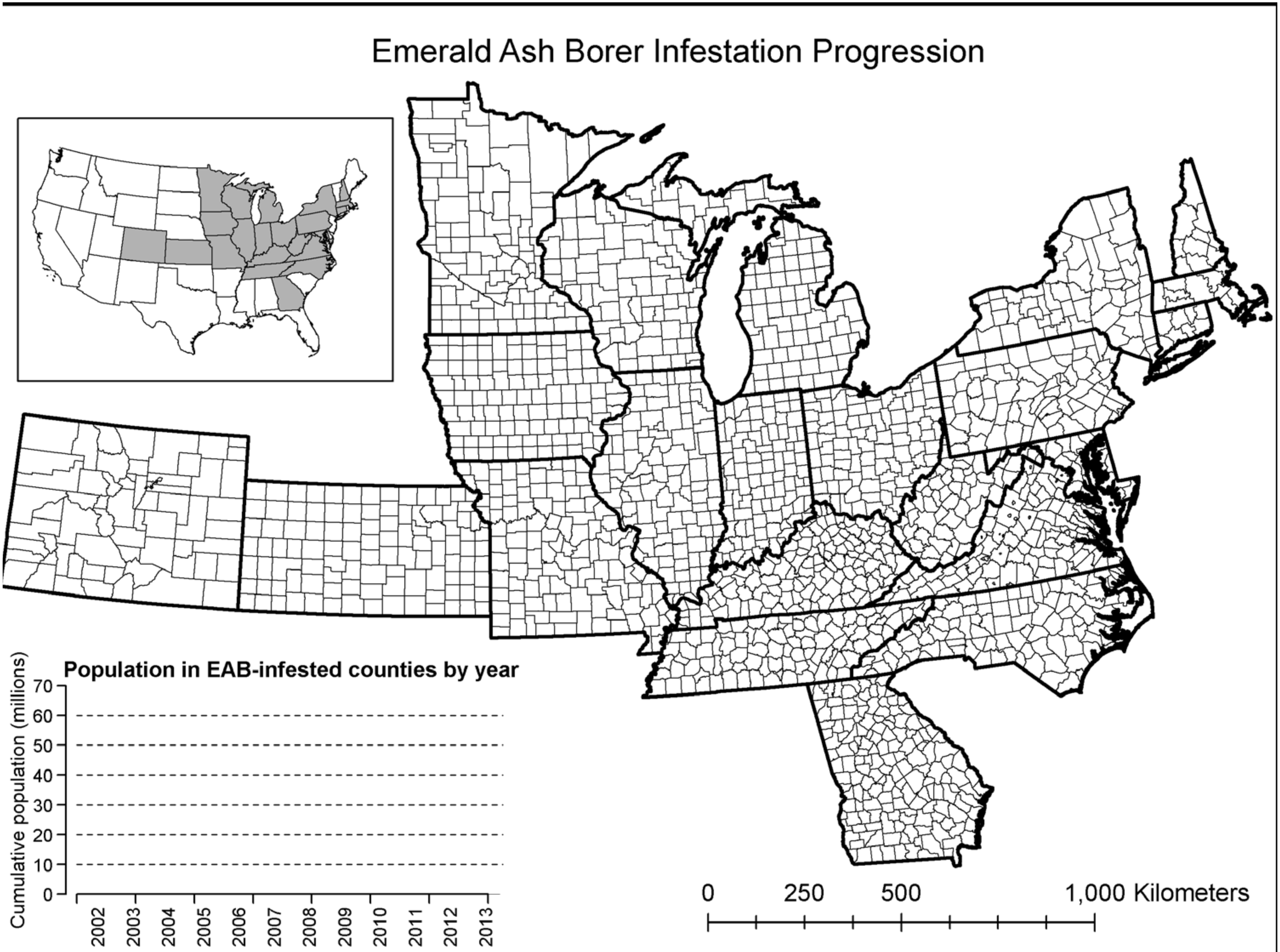


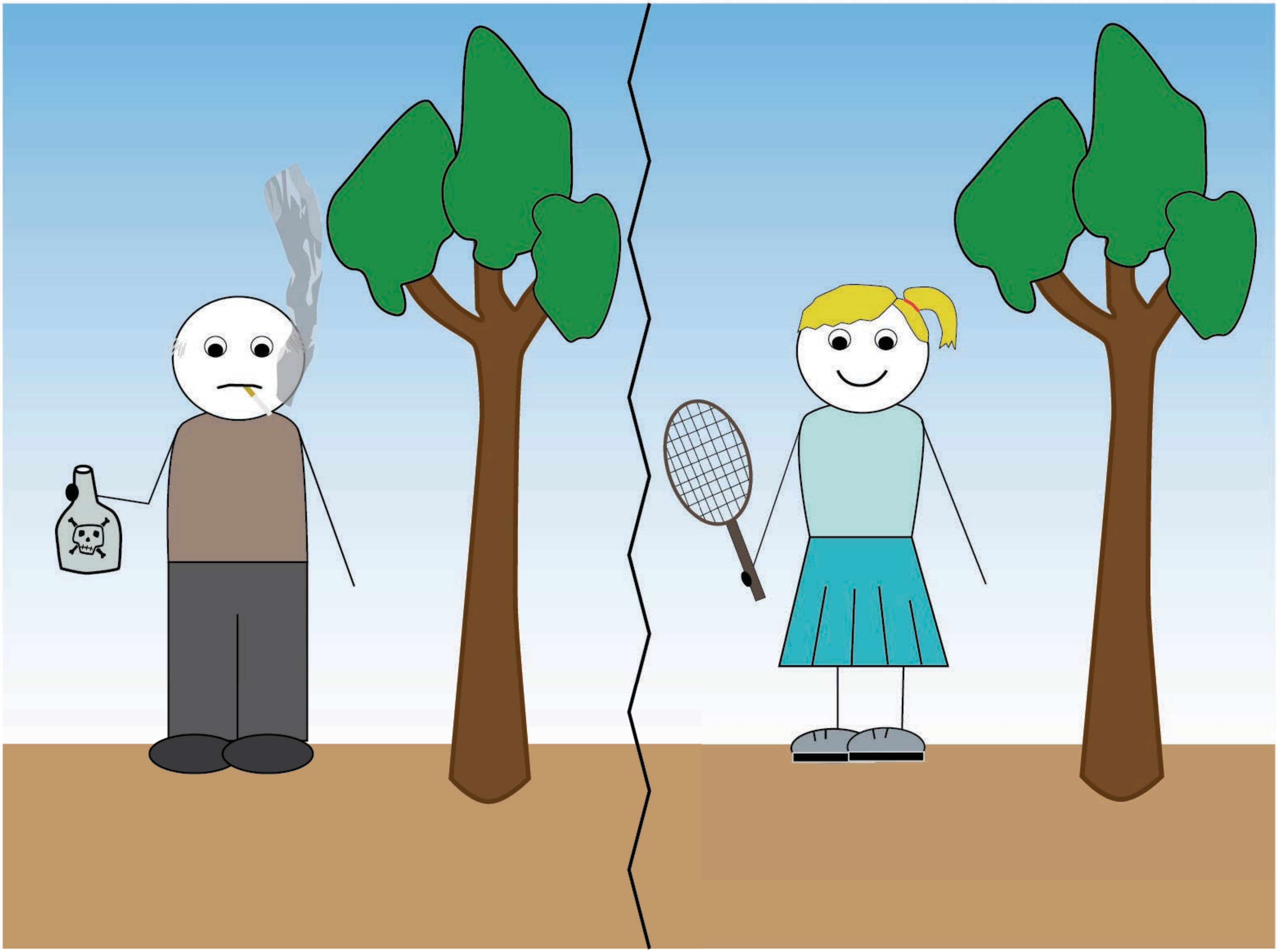


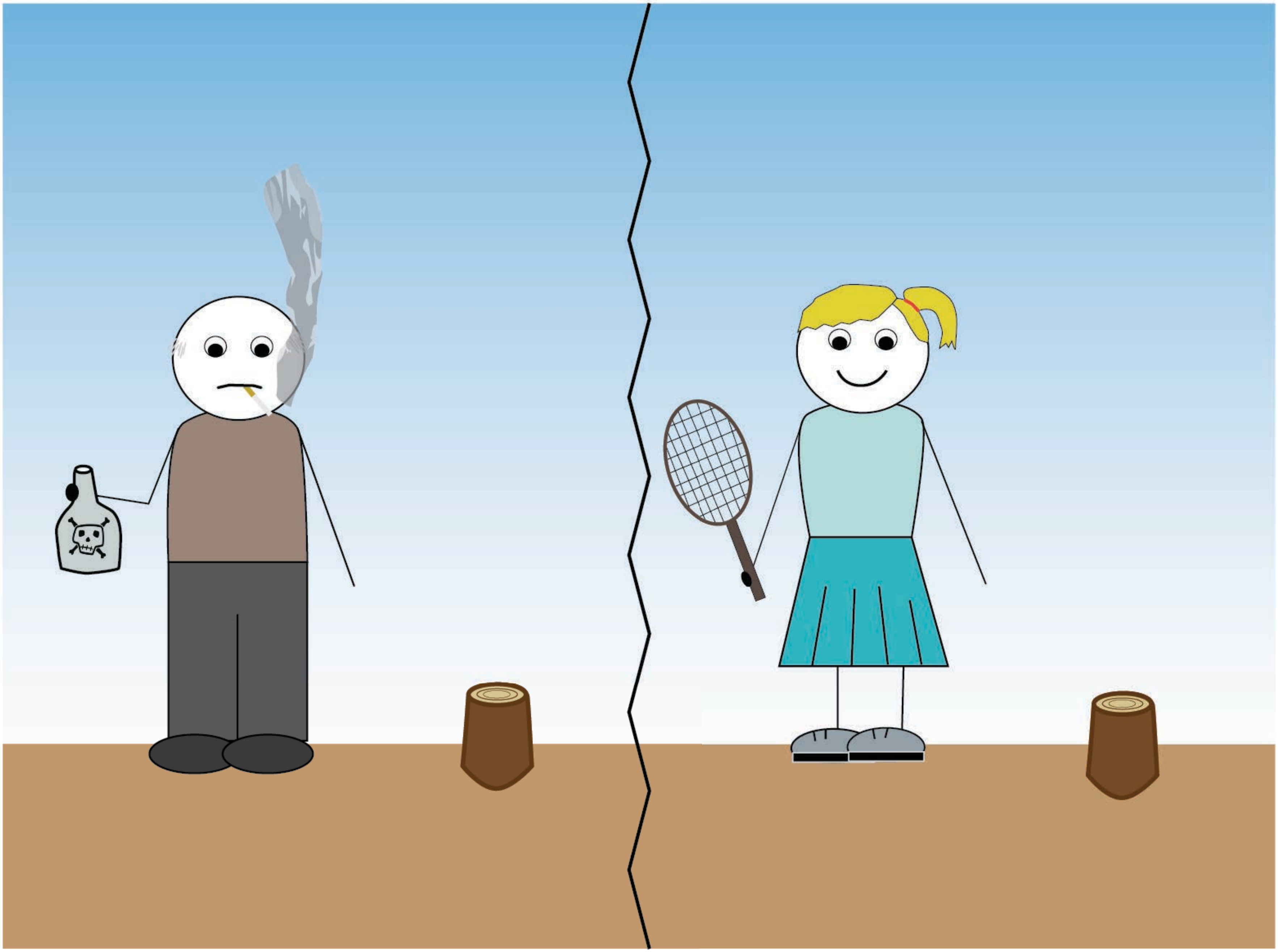


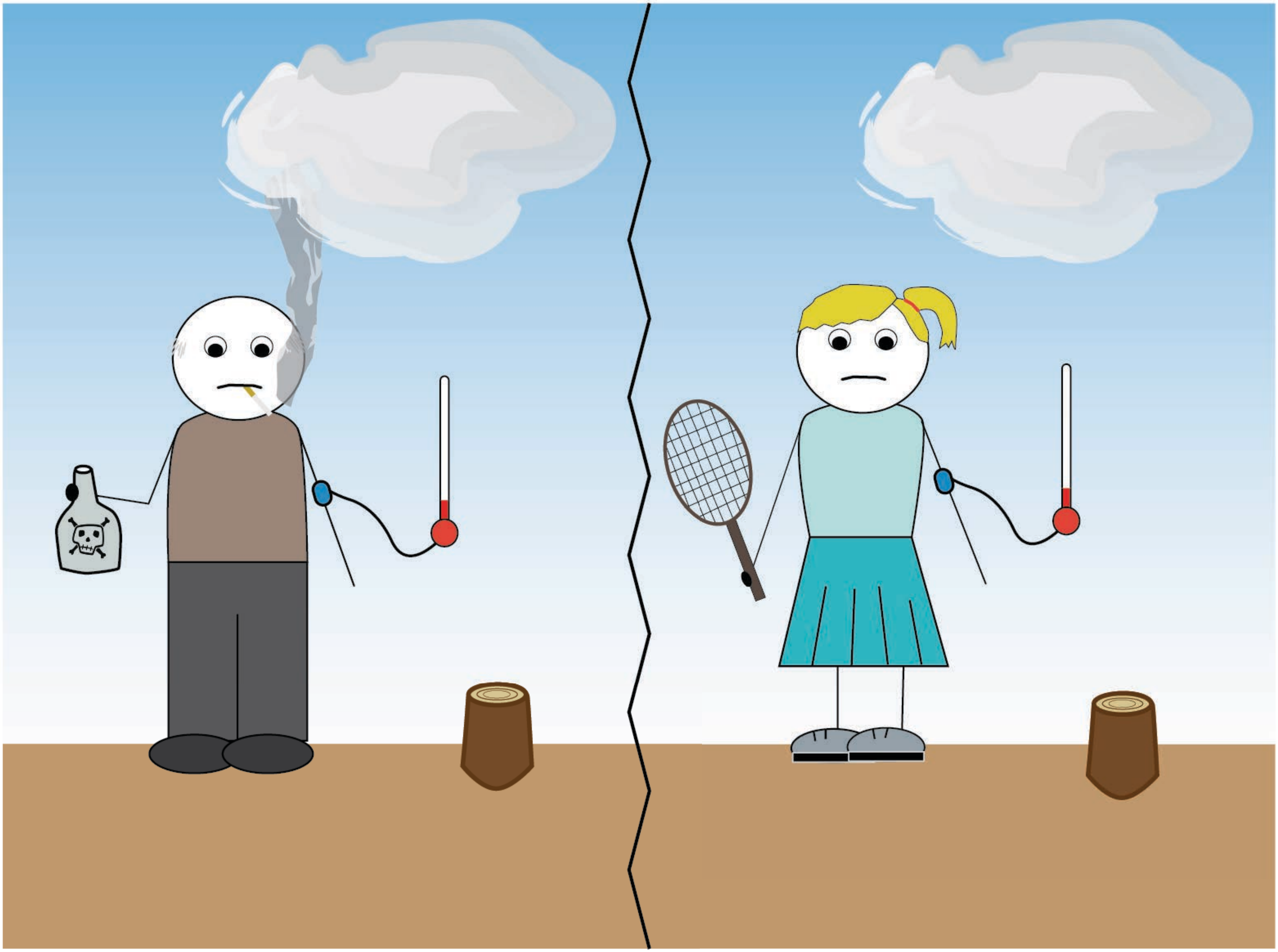


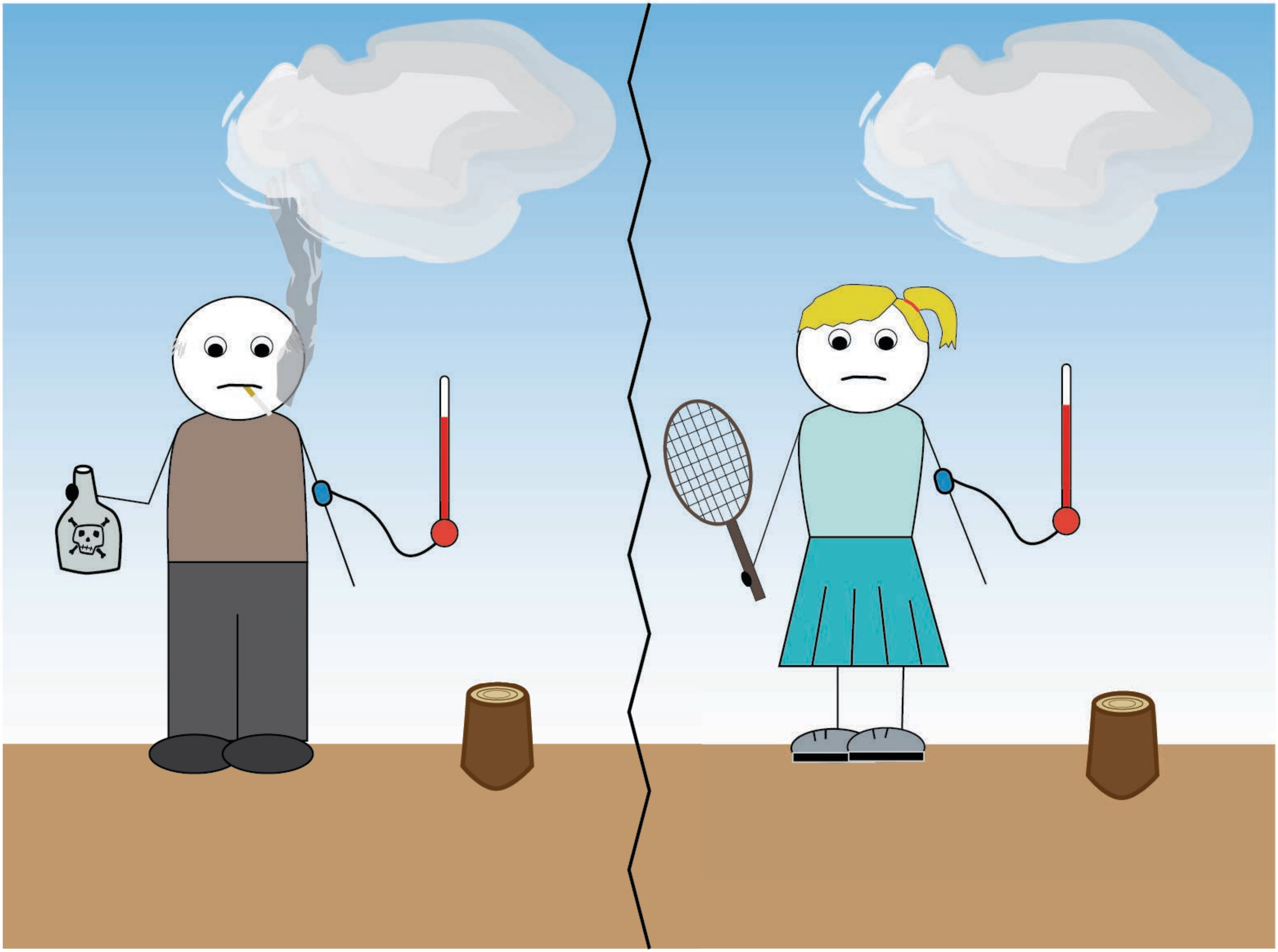


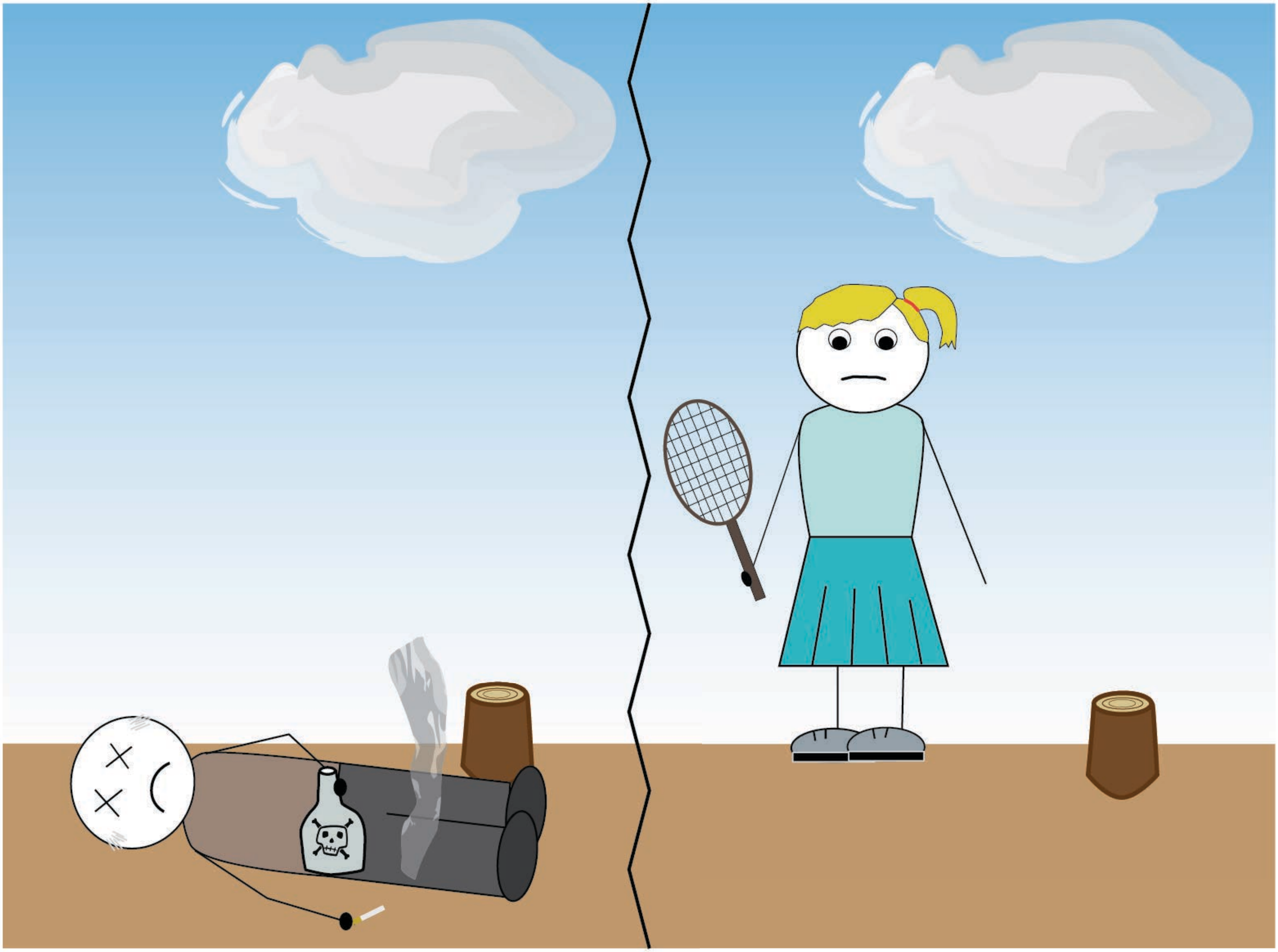

Emerald Ash Borer Infestation Progression
Population in EAB-infested counties by year
Cumulative population (millions)
70
60
50
40
30
20
10
0
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
0
250
500
1,000 Kilometers







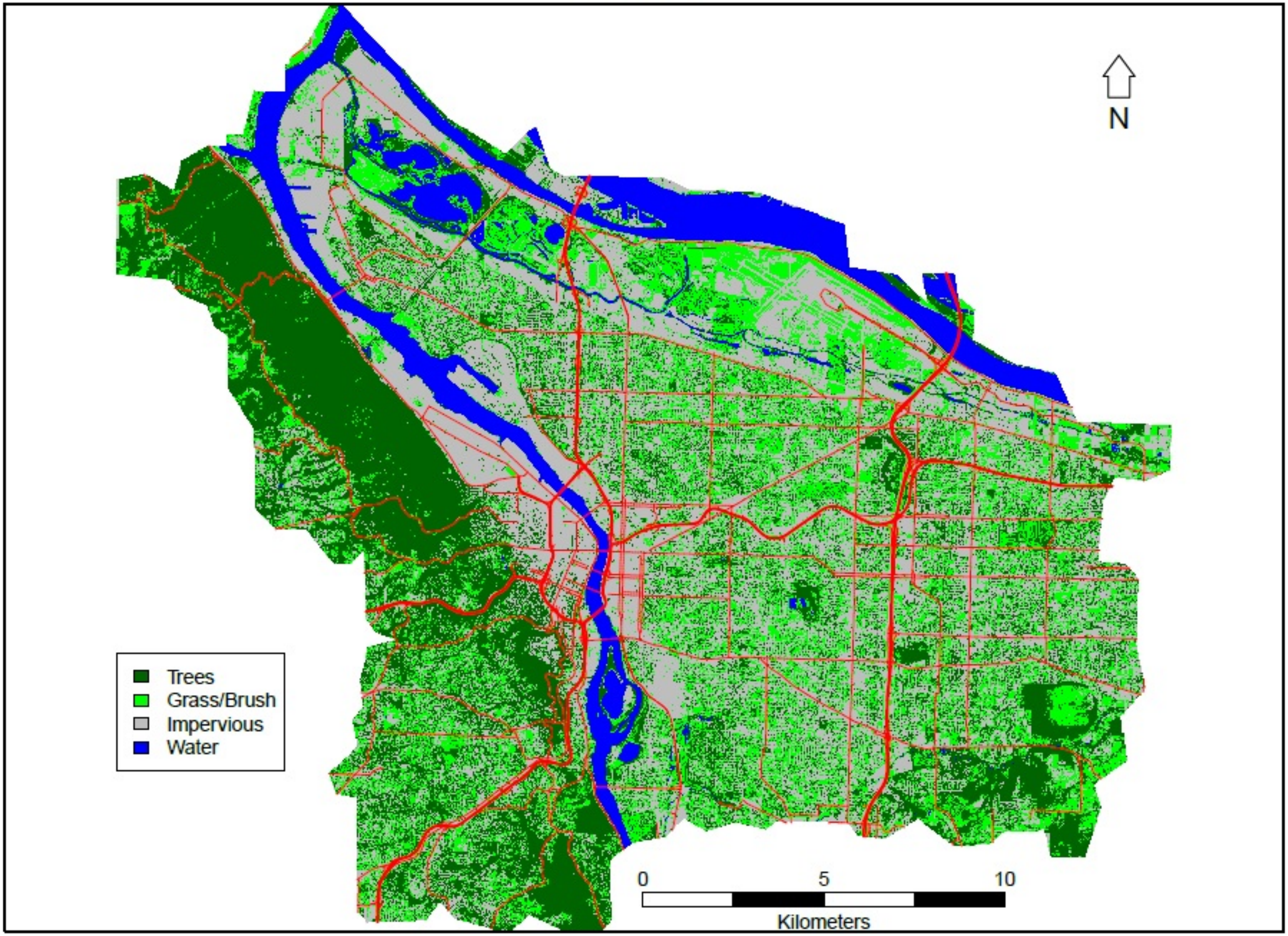




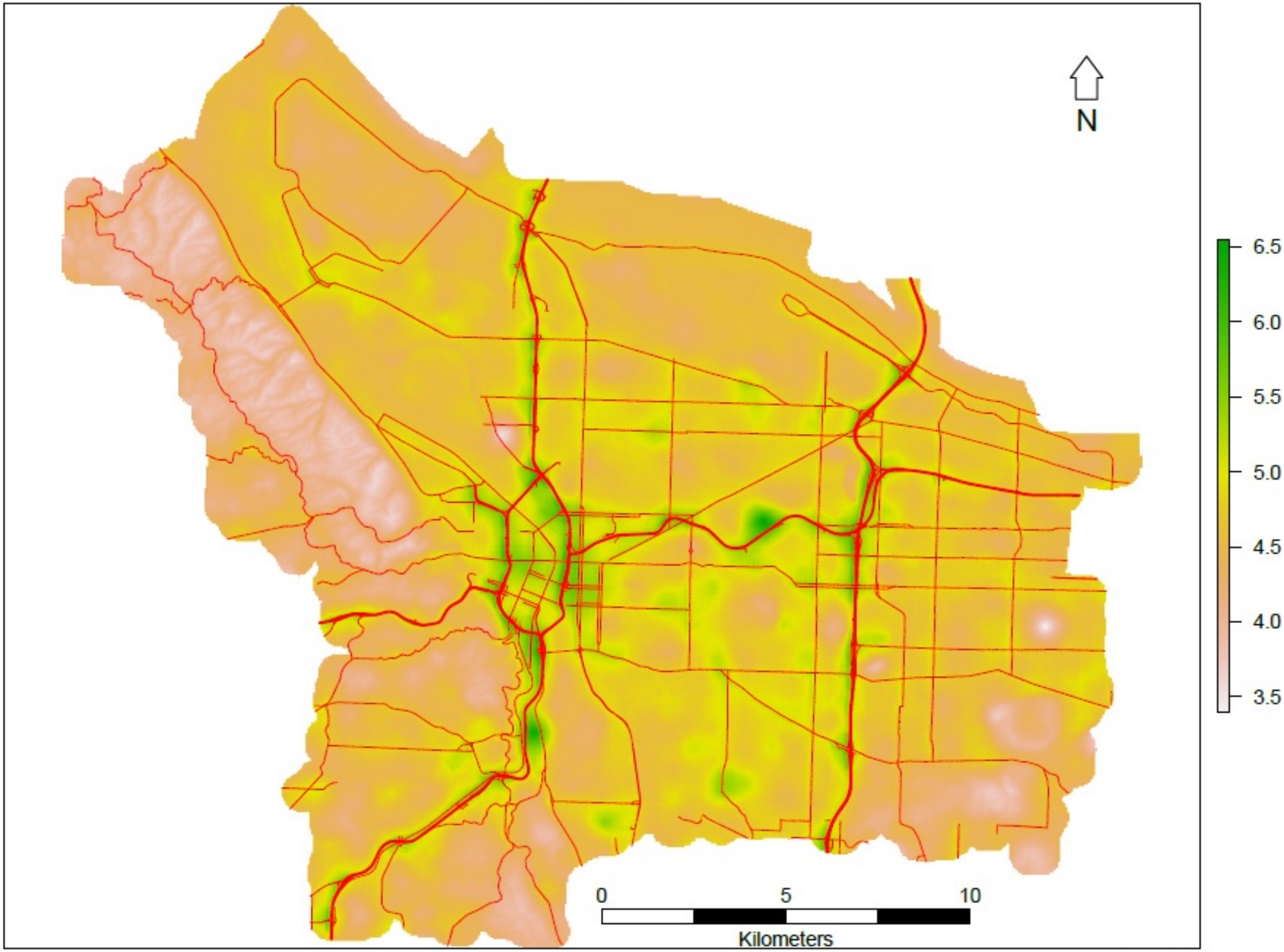

12/03/2013 11:47


12/04/2013 15:59

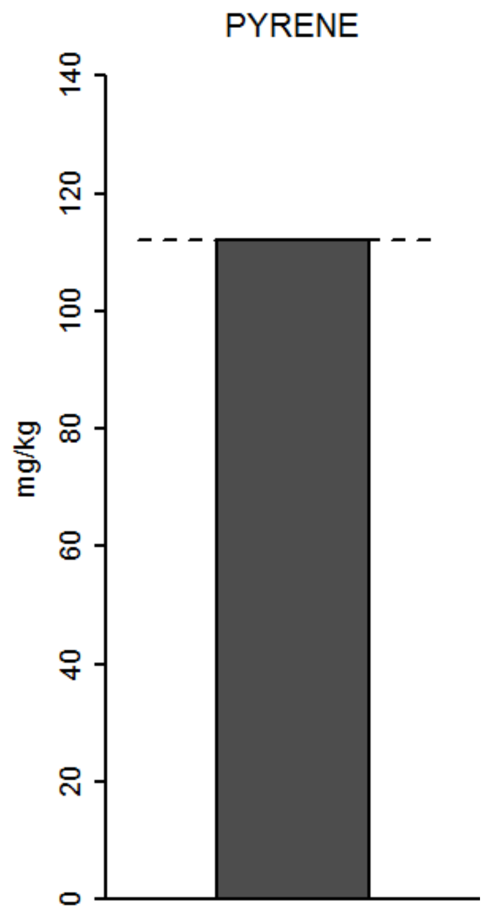
Land Cover



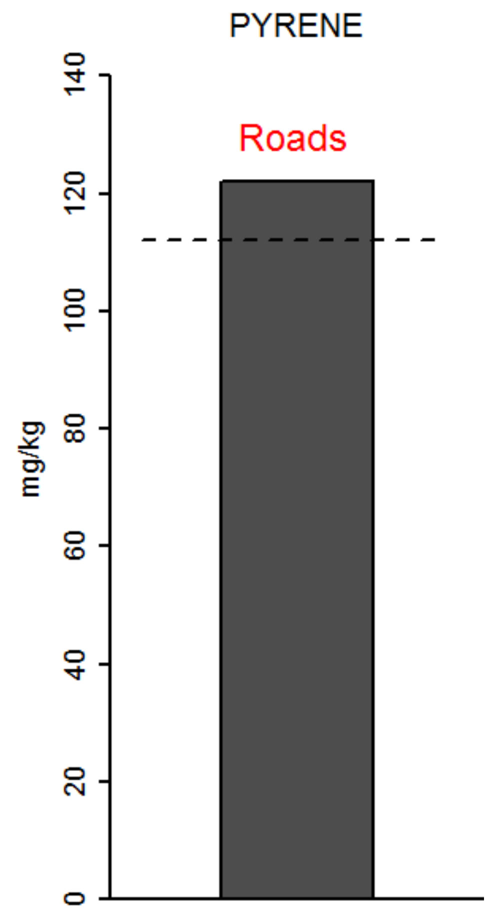
PYRENE

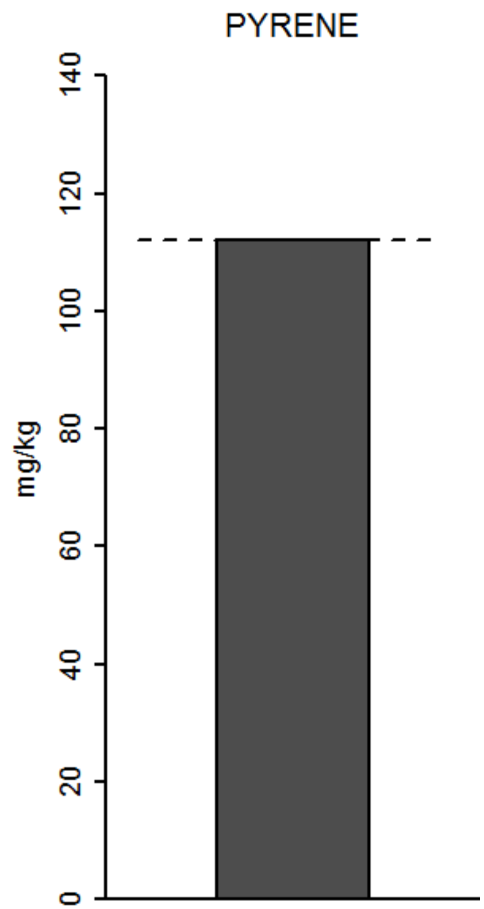


2015Jan15

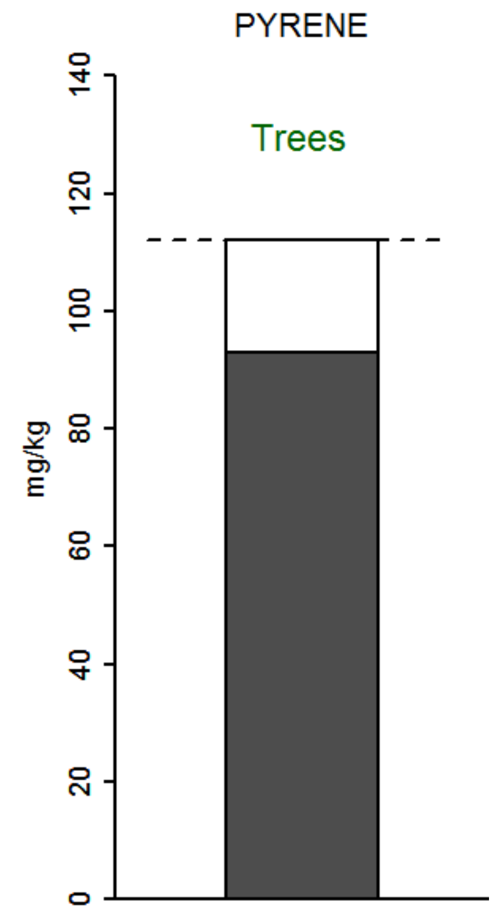


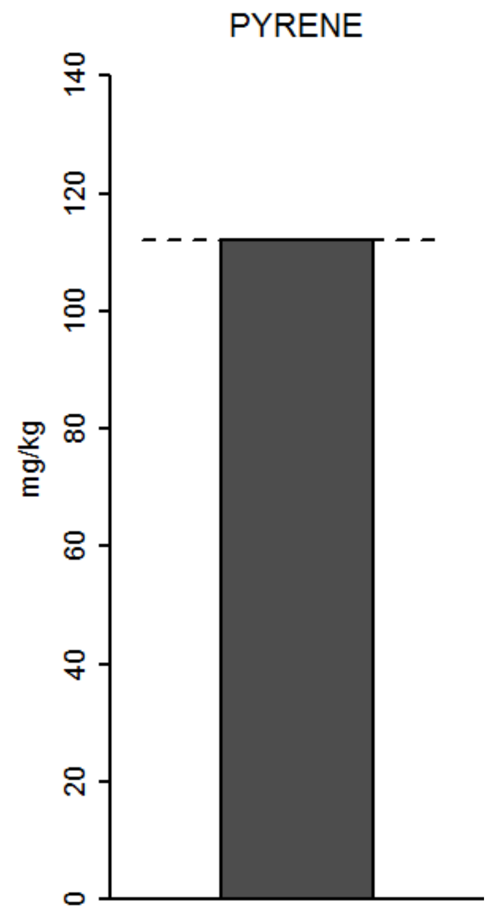
PYRENE
mg/kg
0
20
40
60
80
100
120
140

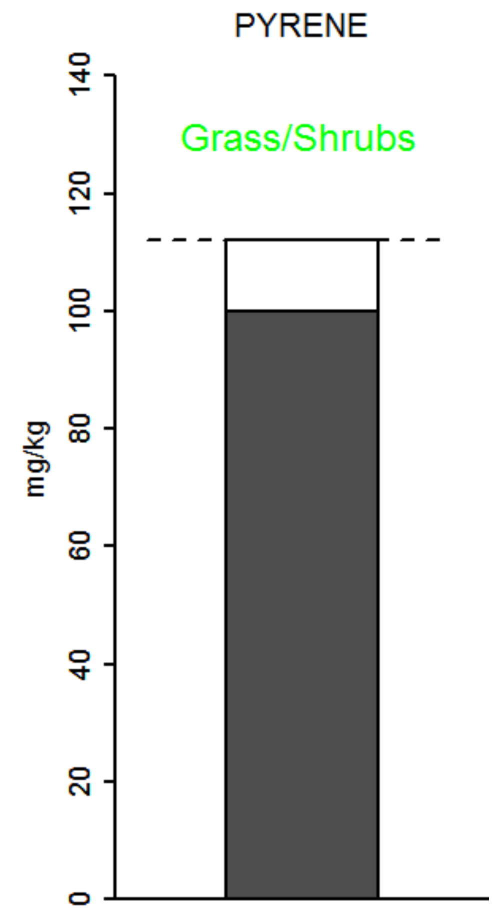

PYRENE
Roads
mg/kg
0
20
40
60
80
100
120
140



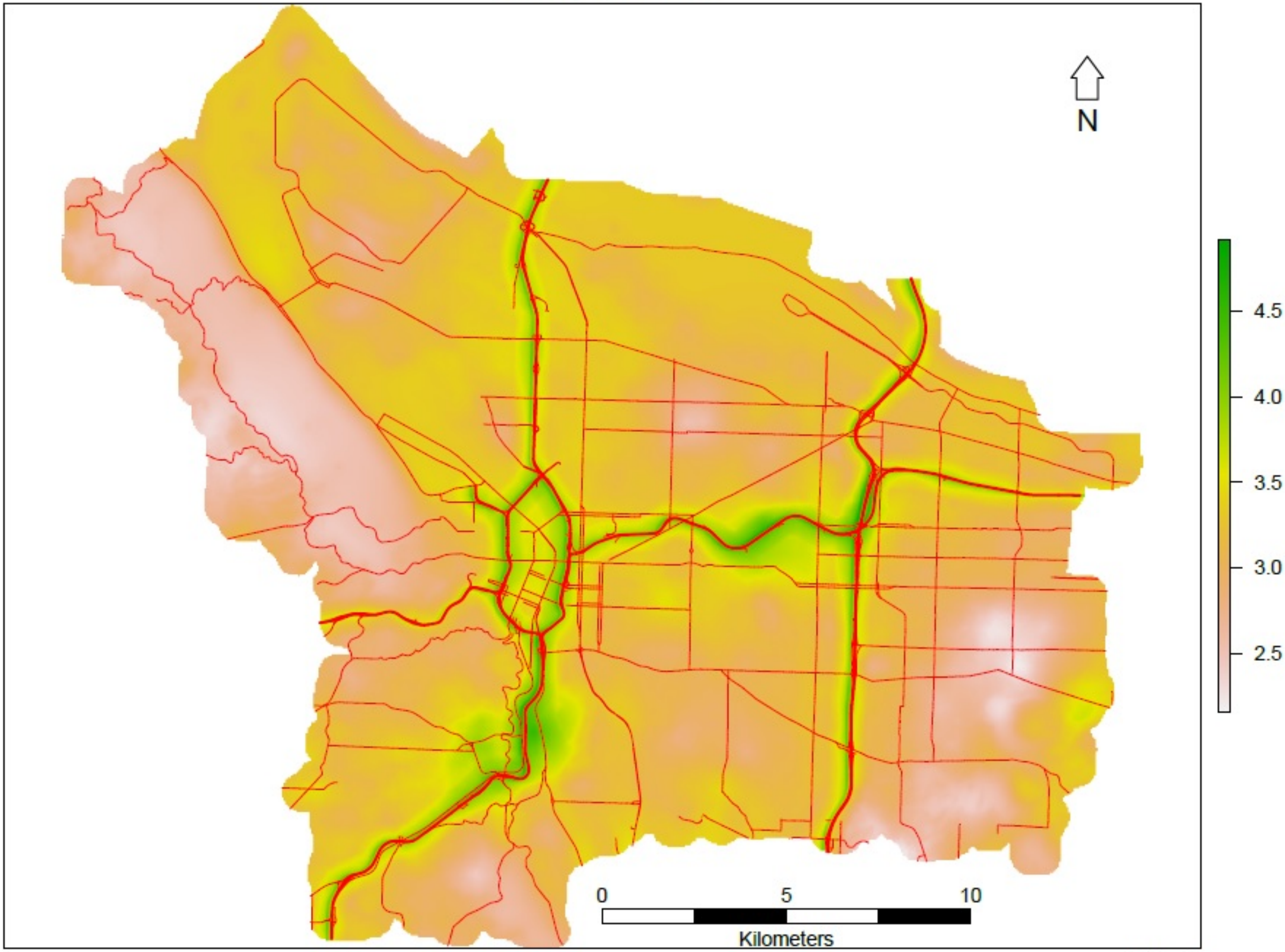
PYRENE
mg/kg
0
20
40
60
80
100
120
140


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

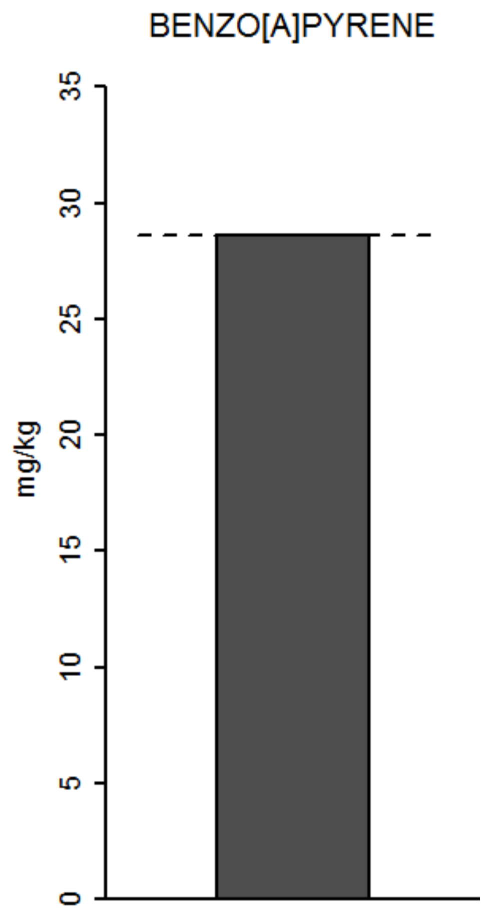

PYRENE
mg/kg
0
20
40
60
80
100
120
140

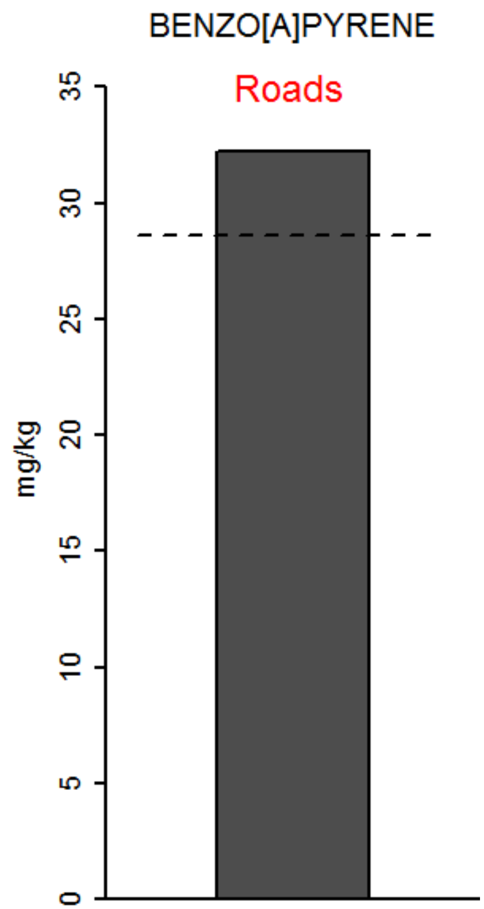

PYRENE
Grass/Shrubs
mg/kg
0
20
40
60
80
100
120
140

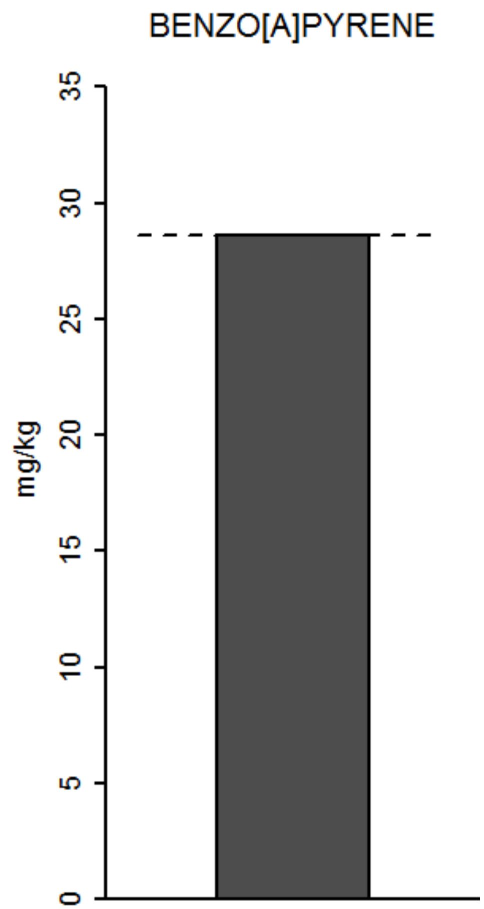
BENZO(A)PYRENE

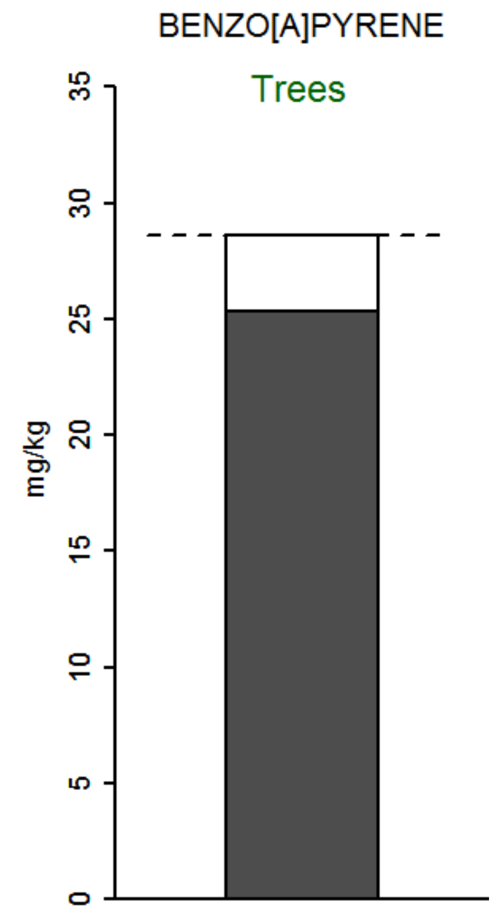


2015Jan15


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