Supplement 1

Supplementary figures and tables appear in the order to which they are referred in the main body of the text. Table S1 lists the items used to create each of the constructs for risk and protective factors described in the Method section. Table S2 describes the demographic distribution of past-year marijuana use, past-year marijuana use disorders, and past-year marijuana use disorders among past-year users. Tables S3 and S4 list the time-trend analyses for each of the nine risk and protective factors among marijuana non-users and among the full sample, and Figure S1 shows plots of trends for each factor. Tables S3 and S4 are intended for comparison with Table 2, which lists the trend analyses for risk and protective factors among past-year marijuana users. Table S5 lists the results of analyses that estimated the trend in past-year conditional prevalence of marijuana dependence, adjusted for each of the 4 risk and protective factors that were identified as potential explanatory variables for the trend toward lower conditional prevalence of marijuana dependence.

Selection, Construction, and Analysis of Risk and Protective Factor Measures

The National Survey on Drug Use and Health (NSDUH) regularly administers a "youth experiences" module that has remained unchanged from 2002 through 2013. A variety of risk and protective factors are queried. From the entire module, we selected items based on the following criteria: (1) They were measured using multiple items (with one exception) and (2) They were not obviously a result of reverse causation. For example, we omitted items related to number of drug-using acquaintances and attitudes towards friends' drug use, reasoning that those are outcomes of drug use as much as likely causes. Although the variables that were selected were also likely to be somewhat influenced by drug use, most represent well-known precursors to drug use (e.g., conduct problems, parental monitoring, religiosity).

The "Arguing with parents" construct was assessed using a single item; it was retained because it was related to the "conduct problems" items, but it was scored separately because it was approximately

normally distributed, whereas the other conduct items were highly skewed. Constructs for attitudes toward school, activity participation, parental monitoring, parental affirmation, drug education, and religious commitment were created using item response theory (IRT) in SAS Proc IRT. Briefly, we fitted each set of items to a single-factor graded response model. We examined the degree to which overall variance among the items was explained by the IRT function (R^2, as determined from eigenvalues), and the item discrimination coefficients (β). For constructs that explained less than 60% of the total variance, we removed the poorest-fitting item, as determined by the item discrimination coefficient. If the construct still did not explain 60% of the variance, we removed a second item. This process resulted in one item being removed from the conduct problem construct, one item being removed from the activity participation construct, and two items being removed from the parental monitoring construct (see Table S1). Histograms for individual items and construct scores were examined to determine whether the distributions were approximately normal. The scores for conduct problems and perceived parental drug attitudes were highly skewed. Both the conduct problem and parental attitude counts were log-transformed to reduce skewness.

All nine risk/protective factor constructs were converted to a standard-normal scale with a mean of zero and standard deviation of 100, so that the magnitude of the time-trend for each could be compared. As discussed in the main body of this paper, we were primarily interested in trends in risk factors among past-year users of marijuana. For comparison, trends in the full sample and among non-users were also calculated, using linear models in which score on each construct was modeled as a function of year. These results are listed in Tables S3 and S4, respectively. Figure S1 also shows plots of mean scores on each risk/protective factor as a function of year.

Table S1: Items Used to Construct Risk and Protective Factor Measures

Risk Factors	
	Beta
Arguing with parents (Single Item). R^2=n/a	
[Responses: 1= "0 times," 2= "1 or 2 times," 3= "3 to 5 times," 4= "6 to 9 times," 5= "10 or more times"]	
1. During the past 12 months, how many times have you argued or had a fight with at least one of your parents?	n/a
Conduct problems (5 Items). R^2=0.63	
[Responses: 1= "0 times," 2= "1 or 2 times," 3= "3 to 5 times," 4= "6 to 9 times," 5= "10 or more times"]	
1. During the past 12 months, how many times have you taken part in a fight where a group of your friends fought against another group?	2.24
2. During the past 12 months, how many times have you sold illegal drugs?	2.35
3. During the past 12 months, how many times have you stolen or tried to steal anything worth more than $50?	1.65
4. During the past 12 months, how many times have you attacked someone with the intent to seriously hurt them?	1.70
5. During the past 12 months, how many times have you gotten into a serious fight at school or work?	2.19
Removed: During the past 12 months, how many times have you carried a handgun?	
Perceived parental drug attitudes (4 items). R^2=0.85	
[Responses: 1= "Neither approve nor disapprove," 2= "Somewhat disapprove," 3= "Strongly disapprove"]	
1. How do you think your parents would feel about you smoking one or more packs of cigarettes per day?	2.62
2. How do you think your parents would feel about you trying marijuana or hashish once or twice?	7.11
3. How do you think your parents would feel about you using marijuana or hashish once a month or more?	15.00
4. How do you think your parents would feel about you having one or two drinks of an alcoholic beverage nearly every day?	2.32
Protective Factors	
Attitudes toward school (4 Items, reverse scored). R^2=0.65	
[Responses: 1= "You liked going to school a lot," 2= "You kind of liked going to school," 3= "You didn't like going to school very much," 4= "You hated going to school" for item 1; similarly scored responses for remaining items].	
1. Which of the statements below best describes how you felt overall	1.68

about going to school during the past 12 months? (responses above)

2. During the past 12 months, how often did you feel that the school work you were assigned to do was meaningful and important? 1.97
3. How important do you think the things you have learned in school during the past 12 months are going to be to you later in life? 1.86
4. How interesting do you think most of your courses at school during the past 12 months have been? 2.41

Activity Participation. R^2=0.67

[Responses: 0= "None," 1= "One," 2= "Two," 3= "3 or more"]

1. During the past 12 months, in how many different kinds of school-based activities, such as team sports, cheerleading, choir, band, student government, or clubs, have you participated? 2.21
2. During the past 12 months, in how many different kinds of community-based activities, such as volunteer activities, sports, clubs, or groups have you participated? 3.01
3. During the past 12 months, in how many different kinds of other activities, such as dance lessons, piano lessons, karate lessons, or horseback riding lessons, have you participated? 0.98

Removed: During the past 12 months, in how many different kinds of church or faith-based activities, such as clubs, youth groups, Saturday or Sunday school, prayer groups, youth trips, service or volunteer activities have you participated?

Parental Monitoring (5 Items, reverse scored). R^2=0.61

[Responses: 1= "Always," 2= "Sometimes," 3= "Seldom," 4= "Never"]

1. During the past 12 months, how often did your parents check if you've done your homework? 2.31
2. During the past 12 months, how often did your parents provide help with your homework when you needed it? 1.69
3. During the past 12 months, how often did your parents limit the amount of time you watched TV? 0.83

Removed: During the past 12 months, how often did your parents make you do chores around the house?

Removed: During the past 12 months, how often did your parents limit the amount of time you went out with friends on school nights?

Parental Affirmation (2 Items, reverse scored). R^2=0.92

[Responses: 1= "Always," 2= "Sometimes," 3= "Seldom," 4= "Never"]

1. During the past 12 months, how often did your parents let you know when you'd done a good job? 4.58
2. During the past 12 months, how often did your parents tell you they were proud of you for something you had done? 4.52

Drug Education (3 Items). R^2=0.67

[Responses: 1= “Yes,” 2= “No”]

1. During the past 12 months have you had a special class about drugs or alcohol in school? 1.56
2. During the past 12 months have you had films, lecture, discussions, or printed information about drugs or alcohol in one of your regular school classes such as health or physical education? 4.66
3. During the past 12 months have you had films, lecture, discussions, or printed information about drugs or alcohol outside of one of your regular classes such as in a special assembly? 1.03

Religious Commitment (4 Items)

[Responses$^{(1q)}$: 1= “0 times,” 2= “1 or 2 times,” 3= “3 to 5 times,” 4= “6 to 24 times,” 5= “25 to 52 times,” 6= “More than 52 times,” Responses$^{(2\text{-}4q)}$: 1= “Strongly disagree,” 2= “Disagree,” 3= “Agree,” 4= “Strongly Agree”]. **R^2=0.70**

1. During the past 12 months, how many times did you attend religious services? (Exclude special occasions such as weddings, funerals, or other special events in your answer.) 1.17
2. Your religious beliefs are a very important part of your life. 3.87
3. Your religious beliefs influence how you make decisions in your life. 5.64
4. It is important that your friends share your religious beliefs. 1.80

Note: R^2 values refer to proportion of overall variance among items explained by the item response theory (IRT) score. Beta refers to discrimination coefficients.

Table S2: Past-Year Prevalence of Marijuana Use, Marijuana Use Disorders, and Marijuana Use Disorders Among Past-Year Users by Demographic Group: 2002-2013

	n (Unweighted)	Marijuana Use	Marijuana Use Disorder	Marijuana Use Disorder Among Users
Adolescents (age 12-17 years)		Prevalence, % (95% CI)	Prevalence (%) 95% CI	Prevalence (%) 95% CI
Full sample	216,852	13.9 (13.7, 14.1)	3.5 (3.5, 3.6)	25.3 (24.6, 25.6)
By age				
12-14 years	105,903	4.8 (4.6, 4.9)	1.1 (1.0, 1.1)	22.9 (21.4, 23.7)
15-17 years	110,949	22.7 (22.3, 22.9)	5.8 (5.7, 5.9)	25.8 (25.1, 26.1)
By race				
White	130,630	14.7 (14.5, 14.9)	3.7 (3.7, 3.8)	25.2 (24.5, 25.6)
Black	29,827	12.7 (12.2, 13.2)	2.8 (2.7, 2.9)	22.1 (20.3, 23.0)
Hispanic	36,856	13.4 (12.9, 13.8)	3.7 (3.5, 3.8)	27.5 (25.7, 28.3)
Other	19,539	10.8 (10.2, 11.4)	2.8 (2.6, 3.0)	26.2 (23.4, 27.6)
By sex				
Males	110,697	14.6 (14.3, 14.9)	3.8 (3.8, 4.0)	26.6 (25.6, 27.1)
Females	106,155	13.2 (12.9, 13.4)	3.1 (3.1, 3.2)	23.8 (22.9, 24.2)

Table S3: Odds Ratios Describing the Association Between Marijuana Use Disorder and Each of Nine Risk and Protective Factors

Variables	**OR**	**(95% CI)**	***p***
Risk Factors			
Arguing with parents	1.774	(1.716, 1.834)	<.001
Conduct problems	3.326	(3.113, 3.553)	<.001
Parental drug attitudes	1.335	(1.285, 1.388)	<.001
Protective Factors			
Attitudes toward school	0.455	(0.419, 0.495)	<.001
Activity participation	0.692	(0.641, 0.747)	<.001
Parental monitoring	0.506	(0.474 ,0.540)	<.001
Parental affirmation	0.567	(0.531, 0.604)	<.001
Drug education	0.908	(0.837, 0.984)	.02
Religious commitment	0.499	(0.462, 0.538)	<.001

Note: Variables were standardized to a mean of zero and a standard deviation of 1, with the exception of "Arguing with parents," which was scored as a 4-point Likert scale.

Table S4: Summary of Results for Models of Marijuana Use Disorder as a Function of Year, Demographics, and Candidate Explanatory Factors, Among Past-Year Marijuana Users

Variables	**OR for year**	**(95% CI)**	***p***
Partially adjusted[a]	0.973	(0.964, 0.981)	<.001
Also Adjusted for:			
Arguing with parents	0.976	(0.967, 0.985)	<.001
Conduct problems	0.999	(0.990, 1.009)	.87
Parental drug attitudes	0.970	(0.960, 0.979)	<.001
Attitudes toward school	0.975	(0.966, 0.984)	<.001
Activity participation	0.977	(0.968, 0.986)	<.001
Parental monitoring	0.976	(0.968, 0.986)	<.001
Parental affirmation	0.971	(0.959, 0.983)	<.001

Note: Each line summarizes one model in which that factor was incorporated in to the demographics-adjusted trend model.
[a]Adjusted for age, sex, and race/ethnicity.

Table S5: Logistic Regression Models for Trend in the Past-Year Prevalence of Use Disorder, Before and After Adjustment for Conduct Problems, Stratified by Age Group

	Partially Adjusted			Fully Adjusted		
	OR	**95% CI**	***p***	**OR**	**95% CI**	***p***
Ages 12-14						
Year	0.973	(0.950, 0.997)	.028	1.002	(0.977, 1.028)[a]	.87
Sex						
Females	*Ref*			*Ref*		
Males	0.990	(0.838, 1.169)	.90	0.694	(0.584, 0.826)	<.001
Race						
White	*Ref*			*Ref*		
Black	0.660	(0.523, 0.833)	<.001	0.434	(0.344, 0.548)	<.001
Hispanic	1.127	(0.904, 1.406)	.29	0.916	(0.736, 1.139)	.43
Other	0.760	(0.563, 1.026)	.07	0.693	(0.503, 0.956)	.03
Conduct score[b]	---			2.433	(2.326, 2.546)	<.001
Ages 15-17						
Year	0.973	(0.964, 0.982)	<.001	0.998	(0.988, 1.008)	.75
Sex						
Females	*Ref*			*Ref*		
Males	1.308	(1.226, 1.394)	<.001	0.978	(0.917, 1.044)	.51
Race						
White	*Ref*			*Ref*		
Black	0.776	(0.701, 0.859)	<.001	0.563	(0.509, 0.622)	<.001
Hispanic	1.022	(0.927, 1.127)	.66	0.865	(0.776, 0.963)	.01
Other	0.778	(0.663, 0.912)	.002	0.791	(0.671, 0.932)	.005
Conduct score[a]	---			1.865	(1.827, 1.903)	<.001

Note: OR = odds ratio.

[a]Fully adjusted OR differs from partially adjusted OR with $p \leq .001$ as determined using bootstrap resampling.

[b]Conduct problems were operationalized using the score derived from item-response theory analyses as described in the Supplementary material. The item response theory (IRT) score was transformed to a scale ranging from zero to 6, which closely approximated a raw count of number of conduct problems endorsed (R=0.95). Thus, the odds ratio approximates the increment in marijuana use disorder risk associated with an increase of one conduct problem.

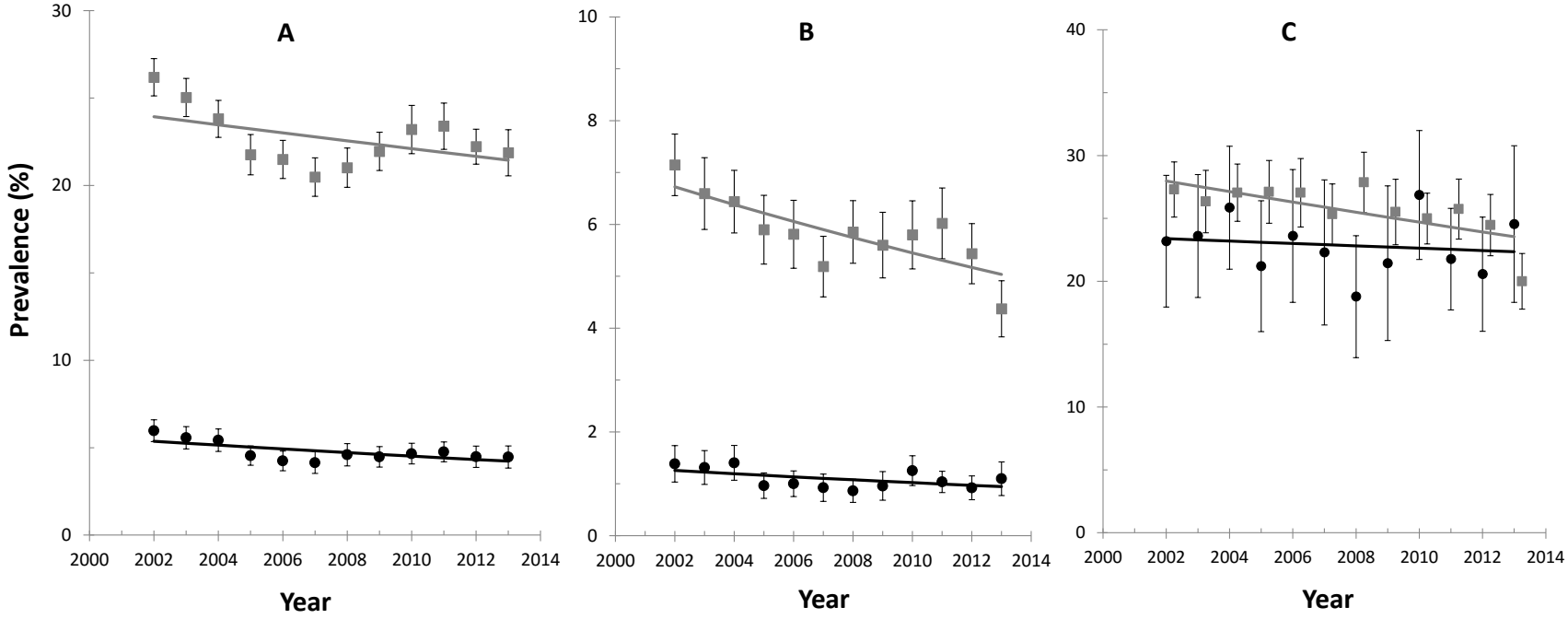

Figure S1: Prevalence of past-year marijuana use (A), past-year marijuana dependence (B), and past-year marijuana dependence among past-year users (C), 2002-2013, separated by age group. Note: Circles/black lines represent estimates for 12–14-year-olds; squares/gray lines represent estimates for 15–17-year-olds. Lines represent fits to linear trend models and are not intended to model the functional form of the trend line. Error bars represent 95% CIs.

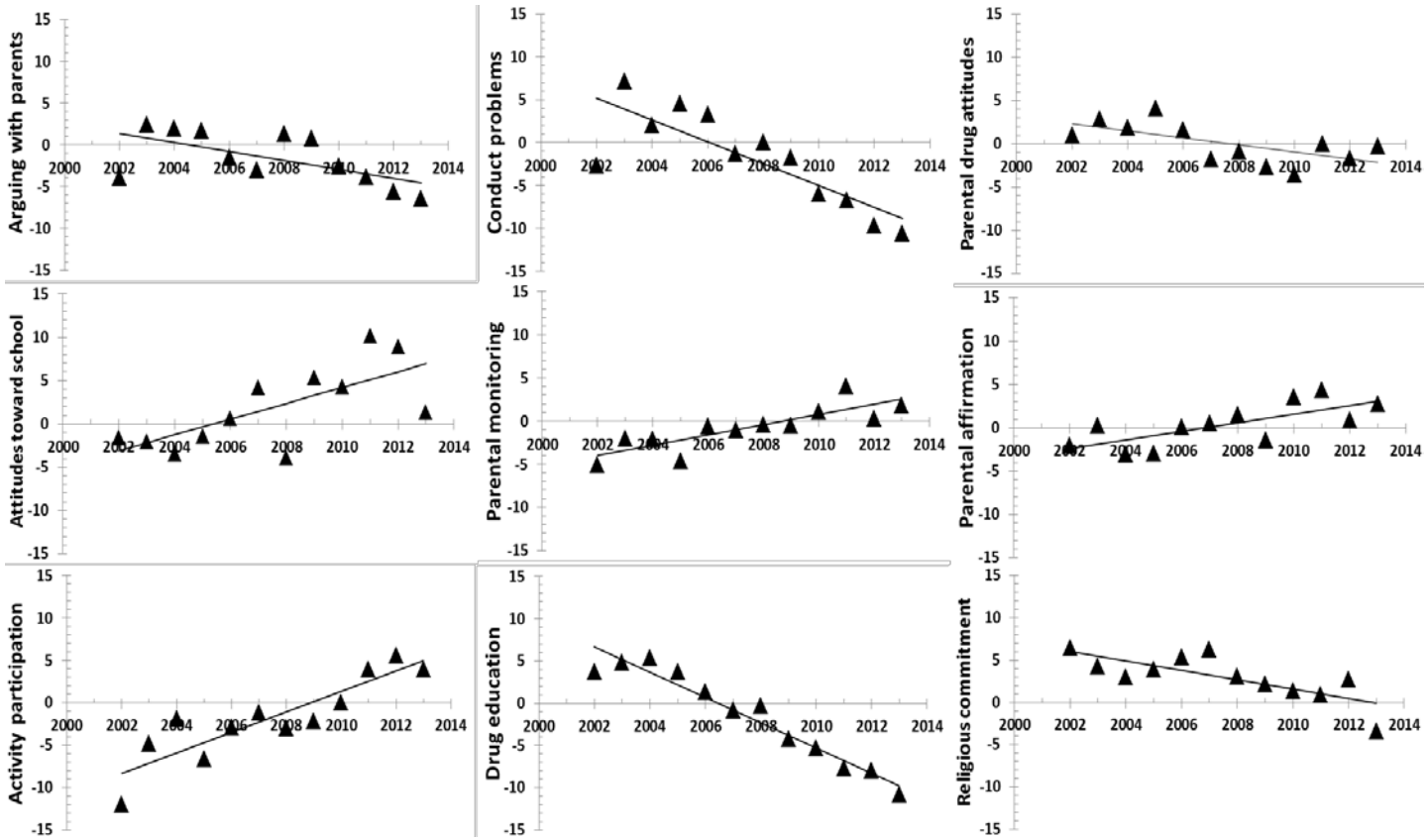

Figure S2: Mean values of scores for nine risk and protective factors for years 2002–2013; the scores were transformed to a standard-normal scale so that magnitudes of change could be compared across factors.

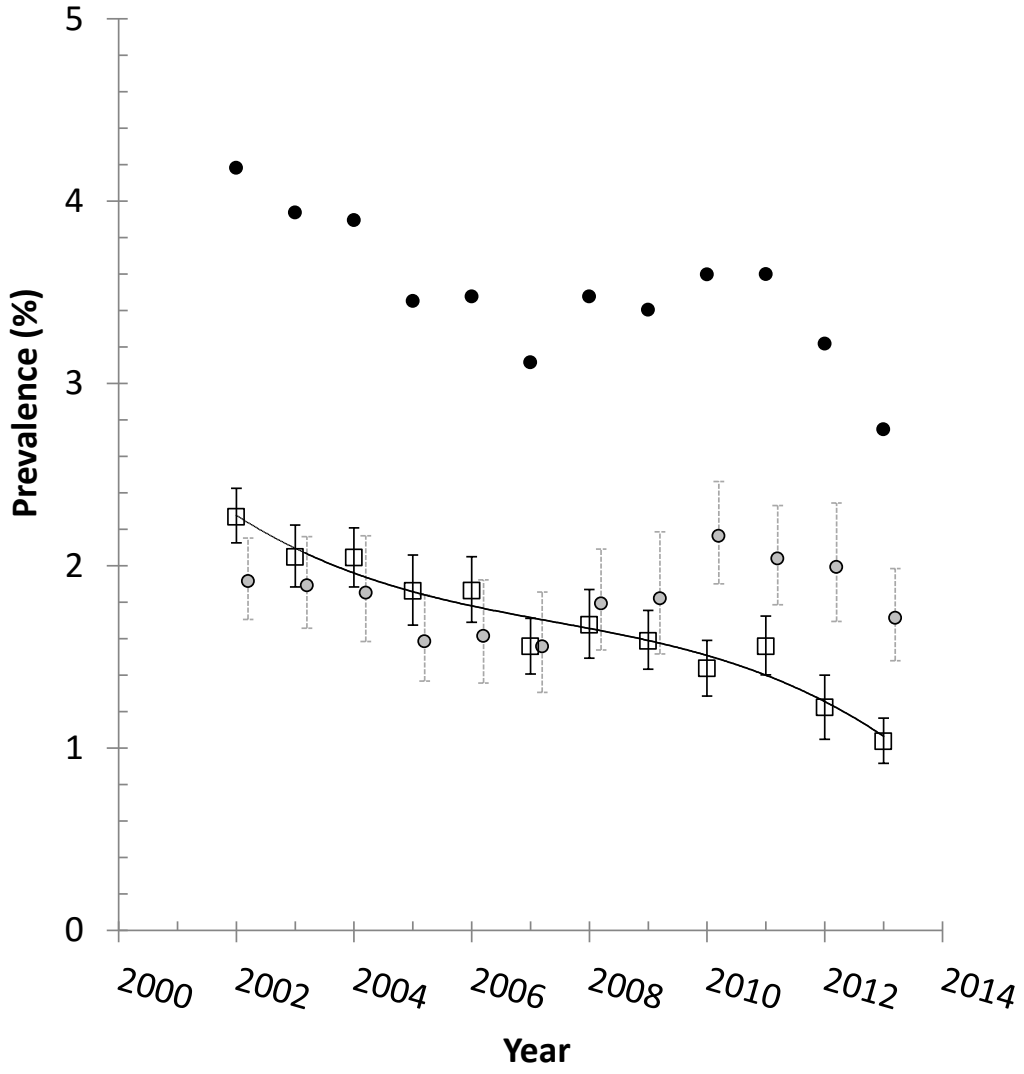

Figure S3: Annual prevalence of marijuana use disorder before and after adjustment for conduct problems. Note: This analysis investigates the role of conduct problems on the trend in marijuana use disorder without assuming linearity of trends. Specifically, the prevalence of marijuana use disorder before and after adjustment for the conduct problem score was estimated separately for each year of data (black circles and gray circles, respectively; error bars omitted from unadjusted prevalence series because these are shown in Figure 1). The adjusted estimate was calculated from the intercept of a logistic regression model with marijuana use disorder as the dependent variable, and the conduct problem score as the independent variable. The objective was to examine whether the difference between these estimates (open squares) decreased over time, as would be expected if adjustment for conduct problems resulted in a flatter trend line. The 95% CIs associated with the difference estimates were determined from bootstrapping resampling analysis using the overall approach described in the main body of the text (last paragraph of Method).

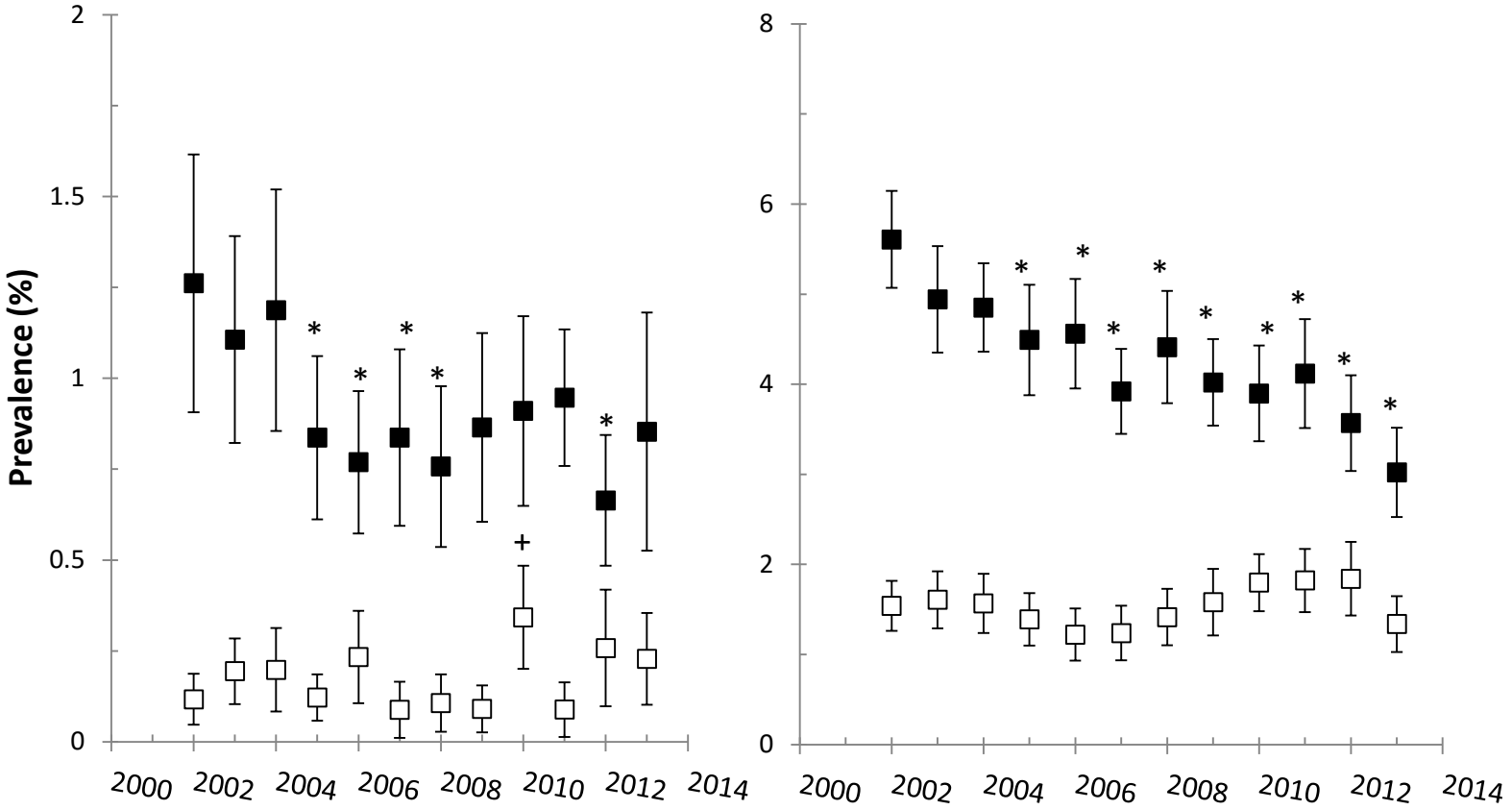

Figure S4: Prevalence of past-year marijuana use disorders with comorbid conduct problems (filled symbols) and with no comorbid conduct problems (open symbols) for ages 12–14 (left) and ages 15–17 (right). Note: Asterisks indicate (*) that the annual estimate is lower than the 2002 estimate at $p<.05$. Plus symbol (+) indicates that the estimate is significantly higher than the 2002 estimate at $p<.05$.