

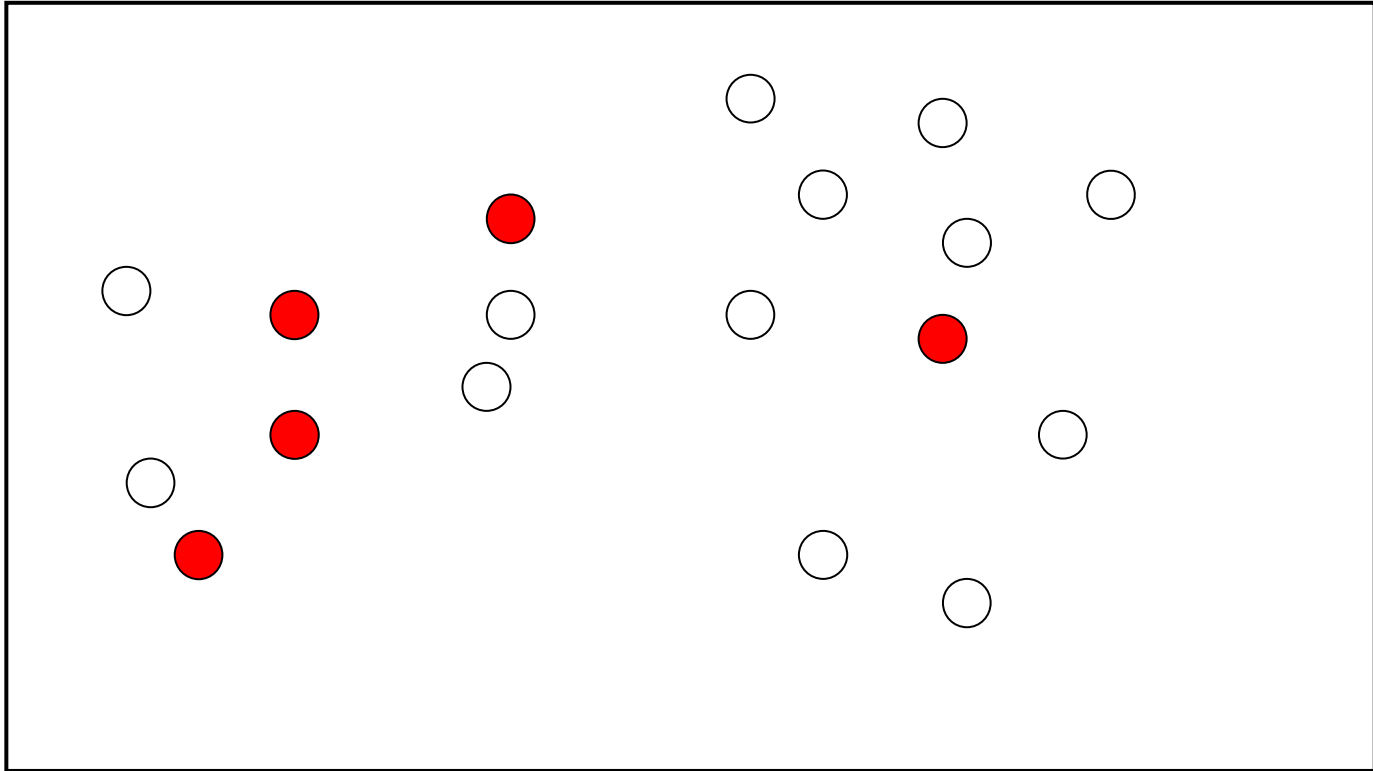
What is Survey Weighting?

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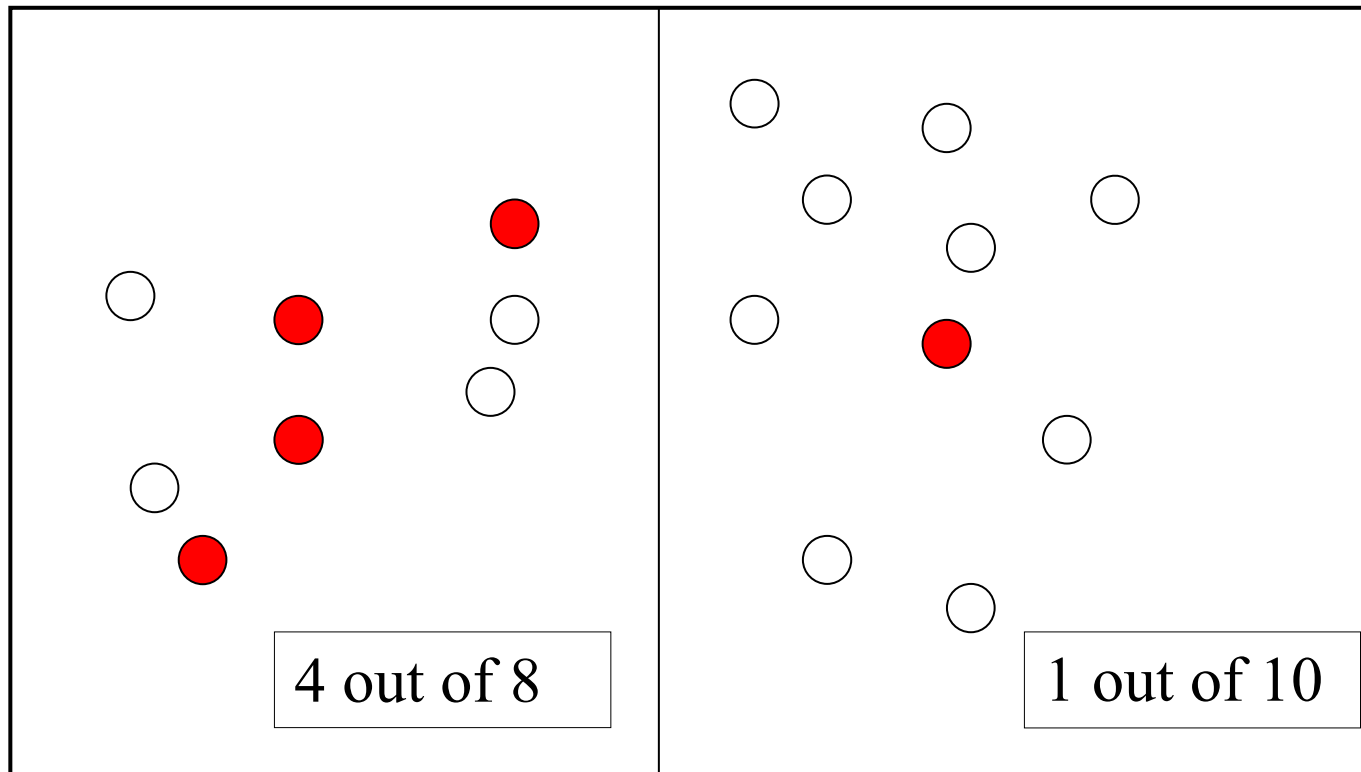
Outline

1. Introduction
2. (Unresolved) Issues
3. Further reading etc.

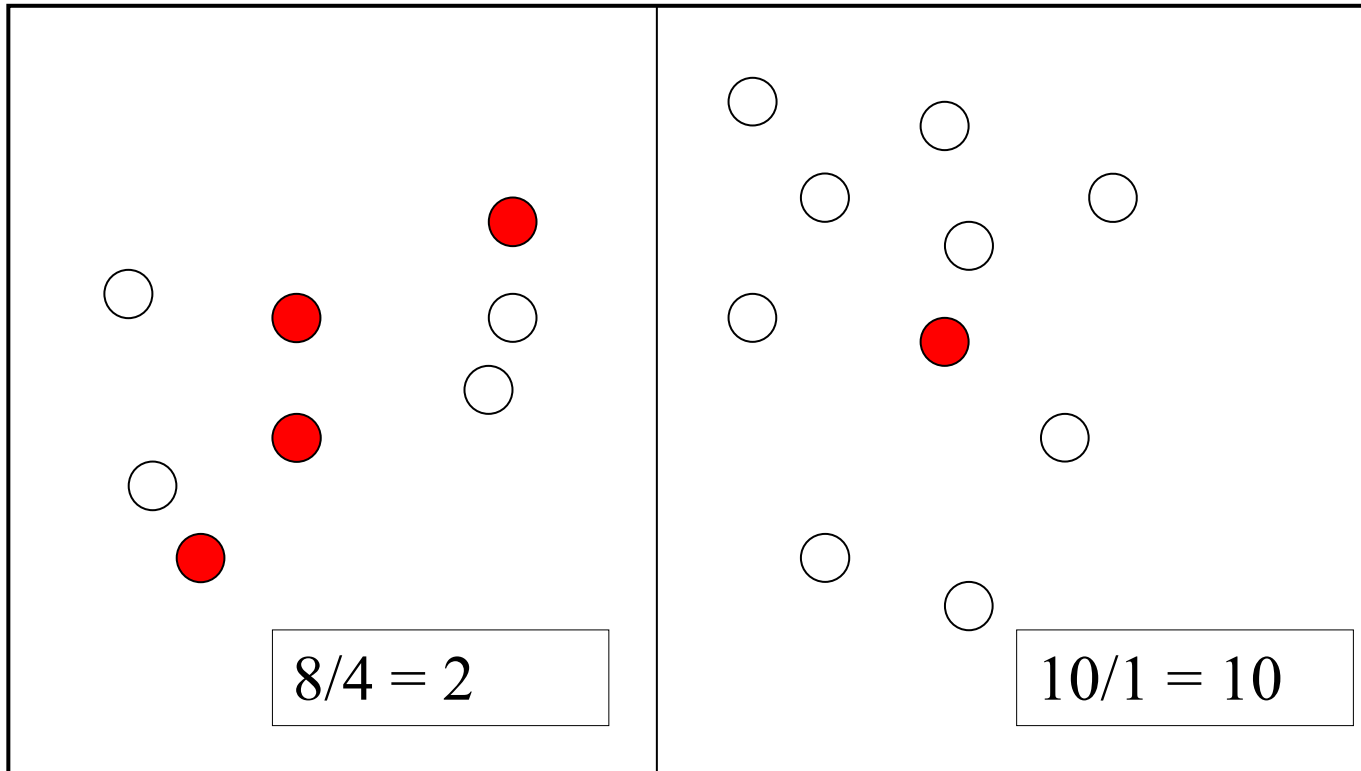
Sampling



Representation



Weights



Data

Sample unit	Weight	Survey variable
1	2	1
2	2	3
3	2	0
4	2	0
5	10	4

Estimation of Mean of Survey Variable

Respondent i	Weight w_i	Survey variable y_i	$w_i y_i$
1	2	1	2
2	2	3	6
3	2	0	0
4	2	0	0
5	10	4	40
<i>Total</i>	<i>18</i>	<i>8</i>	<i>48</i>

Unweighted mean = $8/5 = 1.60$

Weighted mean = $48/18 = 2.67$

Weighted Estimation as Replication

Weighting equivalent to

- (i) replicating each respondent w_i times (provided w_i is integer)
- (ii) using unweighted estimation with replicated dataset

respondent i **represents** w_i population units

Why Weight?

Want to estimate statistical characteristics of population.

If don't weight will estimate characteristics of sample, which may not be representative of population.

Difference between two → **bias** of unweighted estimator.

Example: Workplace Employee Relations Survey 1997

(Purdon, 2004)

	Population	Sample	Sampling fraction (1 in ..)	Weight
10-24	197358	362	545	545
25-49	76087	603	126	126
50-99	36004	566	64	64
100-199	18701	562	33	33
200-499	9832	626	16	16
500+	3249	473	7	7

Example of Bias in WERS

Unweighted employee-level estimates will overrepresent characteristics of employees in larger workplaces

(when population of all employees is of interest).

Weighting needed to avoid bias.

Circumstances when Weighting may be useful

- unequal probability sampling
- non-probability sampling
- nonresponse (usually unit)
- other selection e.g. undercoverage

Construction vs. Use of weights

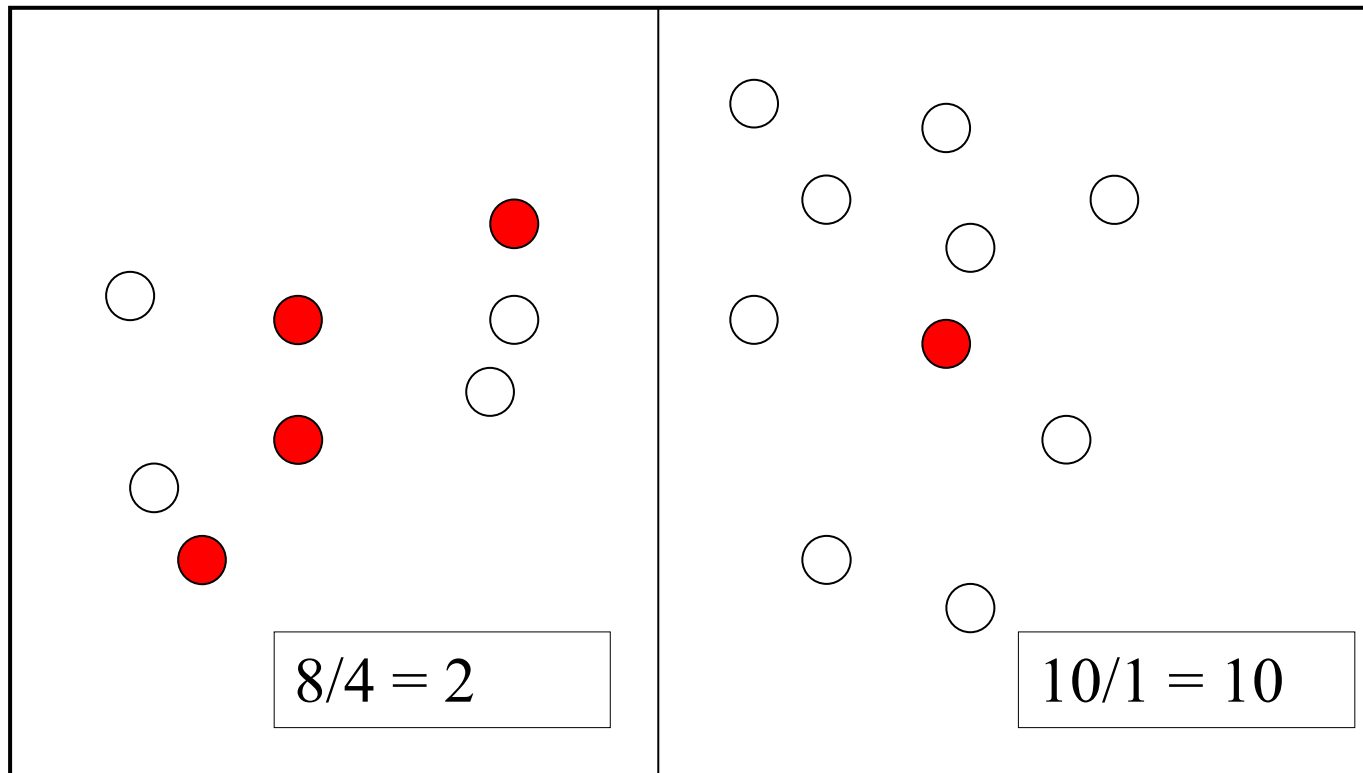
Construction of weights and incorporation into data files by survey agency

- may use detailed information, technical expertise and evaluations not available to standard data user.

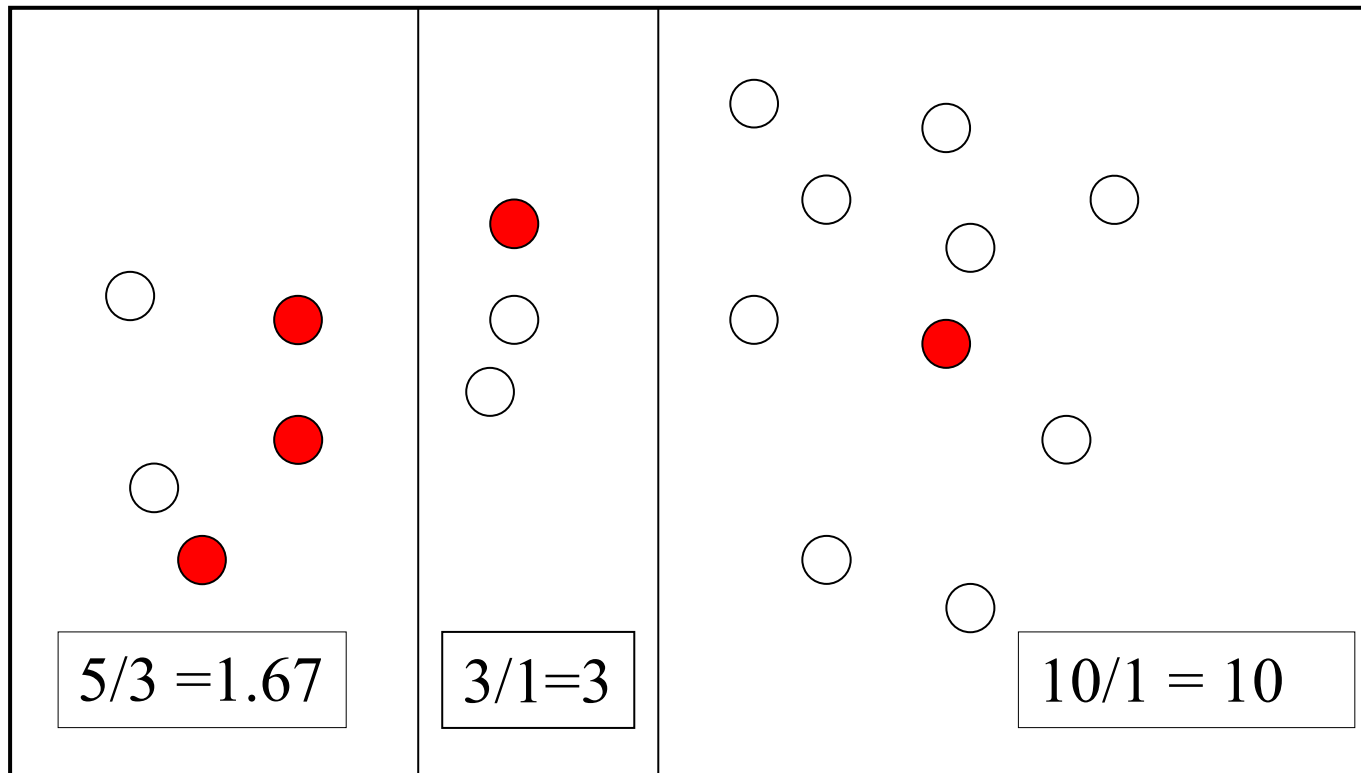
Use of weights by researchers / survey data users

Construction of weights

Weights



Alternative Weights



Approaches to Constructing Weights

Inverse probability weights

(Hansen and Hurvitz, 1943; Horvitz and Thompson, 1952)

Weight = $1 / \text{Probability that unit is selected}$

For probability sampling, assume probabilities of selection 'measurable'

For nonprobability sampling or nonresponse, need to model probability of selection e.g. using logistic regression.

Sometimes called *propensity weights*

Auxiliary Information

Weights use information on *auxiliary variables = weighting variables*

in **population**, e.g. national age-sex population estimates

or (in case of non-response) on **sample**, e.g. characteristics of area in which respondent or nonrespondent lives.

Techniques include *post-stratification, (generalized) regression estimation, raking, calibration estimation.*

Use of Weights

Different kinds of weights:

- *sampling weights* to compensate for unequal sampling probabilities
- *nonresponse weights* to compensate for nonresponse
 - may have alternative weights corresponding to different responding subsamples, e.g. in surveys combining interview & diary
- *final/combined weights* (e.g. combining sampling and nonresponse weights)

- *scaled (standardised) weights*, which sum to 1 or 100 across sample (may be easier to interpret, but not suitable for estimating totals)
- *weights for different units of analysis*, e.g. household vs. individual weights
- *weights for different survey variables*, but usually try to avoid this, weights are multipurpose unlike e.g. imputation

Dependence on assumptions for bias adjustment

Probability sampling – sampling weights can correct for bias without further assumptions

Non-probability sampling and nonresponse – weights only correct for bias under **strong assumption** that selection is unrelated to survey variable, conditional on auxiliary weighting variables

Weighting and Variance

Weighting affects **variance** as well as bias. Can inflate variance or can reduce it. Variance inflation can offset advantage of bias-correction.

Unless, effect is allowed for, **standard errors, confidence intervals, significant tests** etc. produced by standard statistical software can be misleading

Other features of **complex sampling** (stratification and multistage sampling) also affect variance.

Using weighted data

Want software which allows for weighting, stratification and multistage sampling in analysis.

Usually require data file which includes fields for:
weight, stratum and **primary sampling unit**

Software includes:

STATA (version 10+) - svy procedures

SAS (SAS/STAT)

SPSS (version 12+) – Complex sample module

R (Lumley, 2010)

Issues: construction of weights

- which weighting variables to use in particular applications e.g. use of past vote in election polling (Curtice, 2010)
- how many weighting variables to use (and with what detail)?
- whether & how to incorporate social science theory of survey participation in nonresponse weights (Groves and Couper, 1995)

Issues: construction of weights (new methods)

- weighting for multilevel modelling (Pfeffermann, Skinner..., 1998)
- links with biostatistical and econometric literatures on inverse probability and double robust weighting (Kang and Schafer, 2005)

Issues: alternative approaches

- whether (and when) to weight (Fienberg, 2008)
- regression models to control for selection variables as alternative (Gelman, 2007)
- ‘efficient’ statistical modelling approaches (Bayesian, likelihood) (Chambers and Skinner, 2003)
- multiple imputation as alternative, even for unit nonresponse

Future Short Course

Introduction to Survey Sampling and Estimation

Pedro Silva

4th-6th October 2010

Southampton

Courses in Applied Social Surveys

<http://www.s3ri.soton.ac.uk/cass/>

Further Reading

Paper (last updated April 2010) and Presentations at ‘Weighting the Social Surveys’ meeting, **ESDS** Government, March 2004,

<http://www.ccsr.ac.uk/esds/events/past.shtml#weighting>

Practical Exemplars on the Analysis of Surveys (**PEAS**)

<http://www.restore.ac.uk/PEAS/>

(website last updated May 2009)

Heeringa, S.G., West, B.T. and Berglund, P.A. (2010) *Applied Survey Data Analysis*. Boca Raton: CRC Press. (Section 2.7 on Weighting in the Analysis of Survey Data; uses STATA in book but has other software on <http://www.isr.umich.edu/src/smp/asda/>).

Lumley, T. (2010) *Complex Surveys: A Guide to Analysis Using R*. Hoboken: Wiley.

Bethlehem, J. (2009) *Applied Survey Methods: A Statistical Perspective*. Hoboken: Wiley (Chapter 10: Weighting adjustment).

Kalton, G. and Flores-Cervantes, I. (2003) Weighting methods. *Journal of Official Statistics*, 19, 81-97.

Biemer, P. and Christ, S. (2008) Constructing the survey weights. Chapter 16 in P.Levy and S.Lemeshow *Sampling of Populations: Methods and Applications*. Hoboken: Wiley.

Additional References

Chambers, R. and Skinner, C. eds. (2003) *Analysis of Surveys*. Chichester: Wiley.

Curtice, J. (2010) Is it safe to past vote weight? Presented at seminar on “Taking the electoral pulse: three approaches to the methodology of election polling”, January 2010, <http://eprints.ncrm.ac.uk/892/>

Fienberg, S. (2008) To weight or not to weight? A Bayesian Model-based update. Paper presented in Southampton <http://www.s3ri.soton.ac.uk/conferences/ssbs08/papers/14%20Stephen%20Fienberg.pdf>

Gelman, A. (2007) Struggles with survey weighting and regression modelling. *Statistical Science*, 22, 153-164

Groves, R. and Couper, M. (1995) Theoretical motivation for post-survey nonresponse adjustment in household surveys. *Journal of Official Statistics*, 11, 93- 106.

Hansen, M. and Hurwitz, W. (1943) On the theory of sampling from finite populations. *Annals of Mathematical Statistics*, 14, 333-362.

Horvitz, D. and Thompson, D. (1952) A generalization of sampling without replacement from a finite universe. *Journal of American Statistical Association*, 47, 663-685.

Kang, J. and Schafer, J. (2007) Demystifying double robustness: a comparison of alternative strategies for estimating a population mean from incomplete data source: *Statistical Science*, 22, 523-539.

Pfeffermann, D., Skinner, C.J., Holmes, D.J., Goldstein, H. and Rasbash, J. (1998) Weighting for unequal selection probabilities in multilevel models (with discussion). *Journal of the Royal Statistical Society, Series B*, 60, 23-56.

Purdon, S. (2004) Weighting NatCen surveys. Presentation at <http://www.ccsr.ac.uk/esds/events/2004-03-12/slides.shtml>