Part A

Optimal parameters for Naprosyn: c = 3.46, d = 0.84, min = 0.31, max = 1.61

Optimal parameters for Nipro: c = 2.26, d = 0.83, min = 0.47, max = 1.52

Optimal parameters for Anaprox: c = 2.82, d = 0.36, min = 0.15, max = 1.34

Optimal parameters for Norinyl: c = 2.62, d = 0.31, min = 0.31, max = 1.25

Optimal parameters for Pironil: c = 3.25, d = 0.16, min = 0.45, max = 1.09

Optimal parameters for Lidex: c = 2.09, d = 0.39, min = 0.56, max = 1.20

Optimal parameters for Synalar: c = 3.25, d = 0.21, min = 0.59, max = 1.11

Optimal parameters for Nasalide: c = 2.05, d = 0.68, min = 0.16, max = 1.78

Part B

Naprosyn: Optimal salesforce size = 270.51, optimal profit = 221.19

Nipro: Optimal salesforce size = 330.05, optimal profit = 228.62

Anaprox: Optimal salesforce size = 171.69, optimal profit = 12.95

Norinyl: Optimal salesforce size = 71.33, optimal profit = 13.21

Pironil: Optimal salesforce size = 36.88, optimal profit = 26.47

Lidex: Optimal salesforce size = 50.00, optimal profit = 23.96

Synalar: Optimal salesforce size = 30.65, optimal profit = 6.17

Nasalide: Optimal salesforce size = 71.16, optimal profit = 3.49

Part C

Drug	Optimal SF Size (constrained)	% Reduction of SF Size	Optimal Profit (constrained)	% Reduction of Profit
Naprosyn	220.26	18.58	219.55	0.74
Nipro	245.92	25.49	225.90	1.19
Anaprox	117.45	31.59	11.07	14.54
Norinyl	51.53	27.76	12.55	4.99
Pironil	29.49	20.03	26.23	0.92
Lidex	35.54	29.32	23.48	1.99
Synalar	0.00	100.00	4.56	26.03
Nasalide	0.00	100.00	0.91	73.79

We can see that the drugs with the highest percent reductions in salesforce size relative to the unconstrained situation are Synalar and Nasalide. This is likely due to their optimal profit values being very low (4.56 and 0.91, respectively). Presumably, the incremental gain of allocating more personnel to other drugs is much larger, hence why the salesforce sizes for these drugs gets reduced to zero.

The drugs with the lowest percent reductions in salesforce size relative to the unconstrained situation are Naprosyn and Pironil. We can explain this by acknowledging that, in a constrained environment, the best drugs are those that achieve high profits with minimal salesforce personnel. We can thus identify the best drugs by dividing their optimal profit from part B by their optimal salesforce size, also from part B, to obtain a measure of efficiency for each drug. We display these results below:

Drug	**Efficiency (Optimal profit / Optimal SF)**
Naprosyn	0.8177
Nipro	0.6927
Anaprox	0.0754
Norinyl	0.1852
Pironil	0.7177
Lidex	0.4792
Synalar	0.2013
Nasalide	0.0490

We can see from these results that Naprosyn and Pironil have the highest efficiency—that is, relative to their optimal salesforce sizes, their optimal profits are the highest. This explains why they have minimal reductions in salesforce size upon introducing constraints on total salesforce size—they're efficient. Note that, even though Anaprox and Norinyl are less efficient than Synalar according to the above table, Synalar still has a larger percent reduction in salesforce size relative to the unconstrained situation. This is likely caused by the extremely low optimal profit of Synalar overriding this efficiency measure. In other words, this measure of efficiency is useful when commenting on why the salesforce size of each drug changed in a certain way upon introducing constraints, but there are other factors to consider as well.

Part D

Below we provide the mean, median, and standard deviation of the profit at each salesforce size. We also provide two measures of utility. The first measure of utility ("Utility: (Raw)") computes utility (the tradeoff function value) based on the portfolio optimization formula $U = profit_{mean} - \frac{1}{2}A\sigma^2$ where A is the risk aversion coefficient. The second measure of utility ("Utility: (Norm.)") computes utility based on a version of the portfolio optimization formula that scales (normalizes) the standard deviation by a factor of 10 to put it on a similar scale to the mean profit: $U = profit_{mean} - \frac{1}{2}(10)A\sigma^2$. This is because, in the context of a portfolio, expected return and volatility tend to have a similar scale, and we want this to be the case for the mean and standard deviation below. In both tradeoff functions, we use a risk-aversion coefficient of 2.5.

	Salesforce Size										
	100	**134**	**168**	**202**	**236**	**270**	**304**	**338**	**372**	**406**	**440**
Mean	153.27	191.85	209.08	216.26	219.03	219.73	219.37	218.43	217.16	215.68	214.07
Median	152.88	191.81	209.18	216.41	218.91	219.69	219.49	218.47	217.28	215.77	214.24
Std. Dev.	7.33	6.76	6.64	6.61	6.77	6.99	7.19	7.37	7.51	7.62	7.71
Utility (Raw)	144.11	183.40	200.78	208.00	210.57	211.00	210.38	209.23	207.78	206.16	204.44
Utility (Norm.)	61.65	107.31	126.10	133.58	134.40	132.40	129.47	126.37	123.34	120.46	117.73

We can see that the raw utility calculations still lead to an optimal salesforce size of 270 despite taking into account the standard deviations of the profit. This is expected since the mean profits are much larger than the standard deviations. Upon scaling the standard deviations, however, the optimal salesforce size drops to 236. My recommendation to the firm would thus be to use a salesforce size in the range of 225-245 depending on how risk averse they are. If they are more than moderately risk averse (A = 5), I would recommend a salesforce size closer to 200 while a less risk averse company (A = 1) could move closer to the original optimal size of 270. While salesforce sizes higher than 270 yield similar utilities to those less than 270, it makes no sense to hire more personnel for the same utility, so we stick with a recommended salesforce size of 200-270.

Part E

In the Dorfman-Steiner rule, we need to find a balance between price promotions and advertising. That is, since an advertising budget is presumably limited, more advertising means less price promotions and vice versa. With this in mind, lower price elasticity means that we should advertise more since price promotions will be ineffective as a result of this low elasticity and thus our budget is better spent on advertising. In the reverse case, consumers are very price elastic and thus price promotions are a very effective way of boosting sales, so we don't need to advertise as much.