**Model 13: Forestry Problem**

$p_1$: Area of site 1 devoted to growing pine trees
$s_1$: Area of site 1 devoted to growing spruce trees
$w_1$: Area of site 1 devoted to growing walnut trees
$h_1$: Area of site 1 devoted to growing hardwood trees
$p_2$: Area of site 2 devoted to growing pine trees
$s_2$: Area of site 2 devoted to growing spruce trees
$w_2$: Area of site 2 devoted to growing walnut trees
$h_2$: Area of site 2 devoted to growing hardwood trees
$p_3$: Area of site 3 devoted to growing pine trees
$s_3$: Area of site 3 devoted to growing spruce trees
$w_3$: Area of site 3 devoted to growing walnut trees
$h_3$: Area of site 3 devoted to growing hardwood trees
$p_4$: Area of site 4 devoted to growing pine trees
$s_4$: Area of site 4 devoted to growing spruce trees
$w_4$: Area of site 4 devoted to growing walnut trees
$h_4$: Area of site 4 devoted to growing hardwood trees

Objective:

$$\max 16p_1 + 12s_1 + 20w_1 + 18h_1 + 14p_2 + 13s_2 + 24w_2 + 20h_2 + 17p_3 + 10s_3 + 28w_3 + 20h_3 + 12p_4 + 11s_4 + 18w_4 + 17h_4$$

Subject to:
$$17p_1 + 14s_1 + 10w_1 + 9h_1 \leq 1500$$
$$15p_2 + 16s_2 + 12w_2 + 11h_2 \leq 1700$$
$$13p_3 + 12s_3 + 14w_3 + 8h_3 \leq 900$$
$$10p_4 + 11s_4 + 8w_4 + 6h_4 \leq 600$$
$$-17p_1 - 15p_2 - 13p_3 - 10p_4 \leq -22.5$$
$$-14s_1 - 16s_2 - 12s_3 - 11s_4 \leq -9$$
$$-10w_1 - 12w_2 - 14w_3 - 8w_4 \leq -4.8$$
$$-9h_1 - 11h_2 - 8h_3 - 6h_4 \leq -3.5$$
$$p_1, p_2, p_3, p_4, s_1, s_2, s_3, s_4, w_1, w_2, w_3, w_4, h_1, h_2, h_3, h_4 \geq 0$$

**Model 14: Farm Planning**
$a_1$: acres used for farming (up to 600)
$a_2$: additional acres used for farming
$n_1$: number of acres used for normal farming
$n_2$: number of acres used for intensive farming
$p_1$: number of normal poultry units (up to 200)
$p_2$: additional poultry units
$l_1$: free family labor hours
$l_2$: additional labor hours (up to 3000)
$l_3$: additional labor hours after $l_2$ has been exceeded
$c_1$: bushels of corn to purchase for poultry

Objective:

$$\max 155n_1 + 215n_2 + 112.5p_1 + 97.5p_2 - 5a_1 - 8a_2 - 3l_2 - 6l_3 - 3.5c_1$$

$$\begin{aligned}
\text{Subject to: } a_1 &\leq 600 \\
n_1 + n_2 &\leq 1000 \\
n_1 + n_2 - a_1 - a_2 &\leq 0 \\
p_1 &\leq 200 \\
25p_1 + 25p_2 &\leq 150000 \\
25p_1 + 25p_2 - 70n_1 - 100n_2 - c_1 &\leq 0 \\
l_1 &\leq 4000 \\
l_2 &\leq 3000 \\
41n_1 + 59n_2 + 20p_1 + 20p_2 - l_1 - l_2 - l_3 &\leq 0 \\
a_1, a_2, n_1, n_2, p_1, p_2, l_1, l_2, l_3, c_1 &\geq 0
\end{aligned}$$

**Model 17: Farm Fertilizer**
$x_{ij}$: tons of fertilizer type $i$ purchased from shop $j$, $1 \leq i \leq 5$, $1 \leq j \leq 4$
Example: $x_{23}$ is tons of fertilizer type 2 purchased from shop 3

$$\text{Objective: max } -45x_{11} - 13.9x_{21} - 29.9x_{31} - 31.9x_{41} - 9.9x_{51} - 42.5x_{12} - 17.8x_{22} - 31x_{32} - 35x_{42} - 12.3x_{52} - 47.5x_{13} - 19.9x_{23} - 24x_{33} - 32.5x_{43} - 12.4x_{53} - 41.3x_{14} - 12.5x_{24} - 31.2x_{34} - 29.8x_{44} - 11x_{54}$$

$$\begin{aligned}
\text{Subject to: } -x_{11} - x_{12} - x_{13} - x_{14} &\leq -185 \\
-x_{21} - x_{22} - x_{23} - x_{24} &\leq -50 \\
-x_{31} - x_{32} - x_{33} - x_{34} &\leq -50 \\
-x_{41} - x_{42} - x_{43} - x_{44} &\leq -200 \\
-x_{51} - x_{52} - x_{53} - x_{54} &\leq -185 \\
x_{11} + x_{21} + x_{31} + x_{41} + x_{51} &\leq 350 \\
x_{12} + x_{22} + x_{32} + x_{42} + x_{52} &\leq 225 \\
x_{13} + x_{23} + x_{33} + x_{43} + x_{53} &\leq 195 \\
x_{14} + x_{24} + x_{34} + x_{44} + x_{54} &\leq 275 \\
x_{ij} &\geq 0
\end{aligned}$$

**Model 18: Family Farm 2**

$a_s$: number of acres to plant soybeans annually
$a_c$: number of acres to plant corn annually
$a_o$: number of acres to plant oats annually
$d$: number of cows to be purchased
$h$: number of hens to be purchased
$h_w$: excess winter labor hours
$h_s$: excess summer labor hours

$$\max 500a_s + 750a_c + 350a_o + 1000d + 5h + 5h_w + 6h_s$$

$$\begin{aligned}
\text{Subject to: } & a_s + a_c + a_o + 1.5d \leq 125 \\
& 1200c + 9h \leq 40000 \\
& d \leq 32 \\
& h \leq 3000 \\
& 20a_s + 35a_c + 10a_o + 100d + .6h + h_w \leq 3500 \\
& 50a_s + 75a_c + 40a_o + 50d + .3h + h_s \leq 4000 \\
& h_w \leq 3500 \\
& h_s \leq 4000 \\
& a_s, a_c, a_o, d, h, h_w, h_s \geq 0
\end{aligned}$$