Descriptions of Scenarios

Alternative Landscape Futures for North Coast of New South Wales

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Scenario Generation, Modelling and Maps

This document briefly describes the process for modelling and generating each scenario and provides full page maps of each scenario for the entire study region.

Further details on methodologies, modelling and results are available either as accompanying documents or data (on CD). These contain images of northern and southern portions of the study region, spatial data, and the report on the Landscape Classification Routines, the Land Use Land Cover (LULC) change methodology which form the background (and base layers) to the scenario generation.

While visualisation (via the maps) of different scenarios is a valuable and powerful tool, objective comparison and evaluation of the scenarios, against how the landscape was (1980) or is currently (as at 2004), is also valuable to understand change over time. A landscape change table is provided which details the loss or gain of land use or landscape elements for each scenario compared to the landscapes of the region in 2004.

Placement Algorithm

The algorithm and associated code to classify cells as ‘urban’ and hence predict the spatial location of future populations is based on a cellular automata approach. It utilises a separately produced grid that defines buildable areas based on designated constraints to building hence classifying any specific land area as “buildable” or “not-buildable”.

In all of the scenarios generated constraints to building always included existing national parks, areas with a slope greater than 25% as well as any area currently used by major roads. Each individual scenario has additional areas classified as not buildable based upon the requirements for that scenario as explained in the individual scenario description.

Allocation of predetermined amount of cells to urban development was based on population growth calculations, the algorithm will iteratively progress through the study area selecting additional areas until that specified population figure is reached. As the algorithm is based upon cellular automata, selection of new urban cells is dependent upon the proximity and relationship of cells to existing urban areas. This creates a predisposition to select areas adjacent to existing areas and hence build or enlarge neighbourhoods. As many urban areas are developed along major roads the algorithms tendency to select new cells alongside existing urban areas builds upon the trend to develop urban areas and associated infrastructure along major thoroughfares. Further, as areas become popular and experience strong growth they will tend to continue to gain further 'popularity' and hence grow further. These algorithmic trends are quite realistic as they tend to follow 'real world' planning decisions for urban and peri-urban expansion, and which has occurred in the past.

Calculating Population Growth

Population figures were used from the census collection data which provided values for 1981, 1991 and 2001 for each of the 289 collection districts within the region. This allowed for the estimation of future population levels by using linear and exponential trends and examination of levels of population density.

However the study area has a diverse socioeconomic distribution with areas experiencing contrasting levels of growth and population density. As such, some inland areas which although large such as Grafton or Casino are only experiencing low to modest growth whereas many coastal areas are experiencing very a strong growth in population. When the entire area is treated as one region a proportion of the large growth within coastal areas is incorrectly placed in slower growing inland areas, hence the utilisation of a single figure for population levels across the study area is unrealistic.

Calculating estimates for each of 289 collection districts resulted in statistical errors as some spatially small areas have experienced extremely high growth in a ten year period. Once past growth is extrapolated to future years some areas gained population levels in the order of hundreds of thousands of people even though spatially, the entire may be only a few square kilometres. Therefore, it was decided to join collection districts into spatially homogenous zones based on the trend of the underlying districts population level, amount of urban area and the growth of both factors over the previous twenty years. This however has introduced a zone edge or boundary error due to varying population levels and building new areas on boundaries and can be seen by partial circles and sharp off cut off areas along boundary lines. To minimise this boundary effect, over fifty variations of zoning, ranging from two to over twenty zones were created and tested. The six zones finally selected for use (Figure 1) provided the best balance of being large enough to provide realistic estimations of growth while being small enough to allow for the large levels of variation across the region as well as providing relatively few edge or boundary errors.

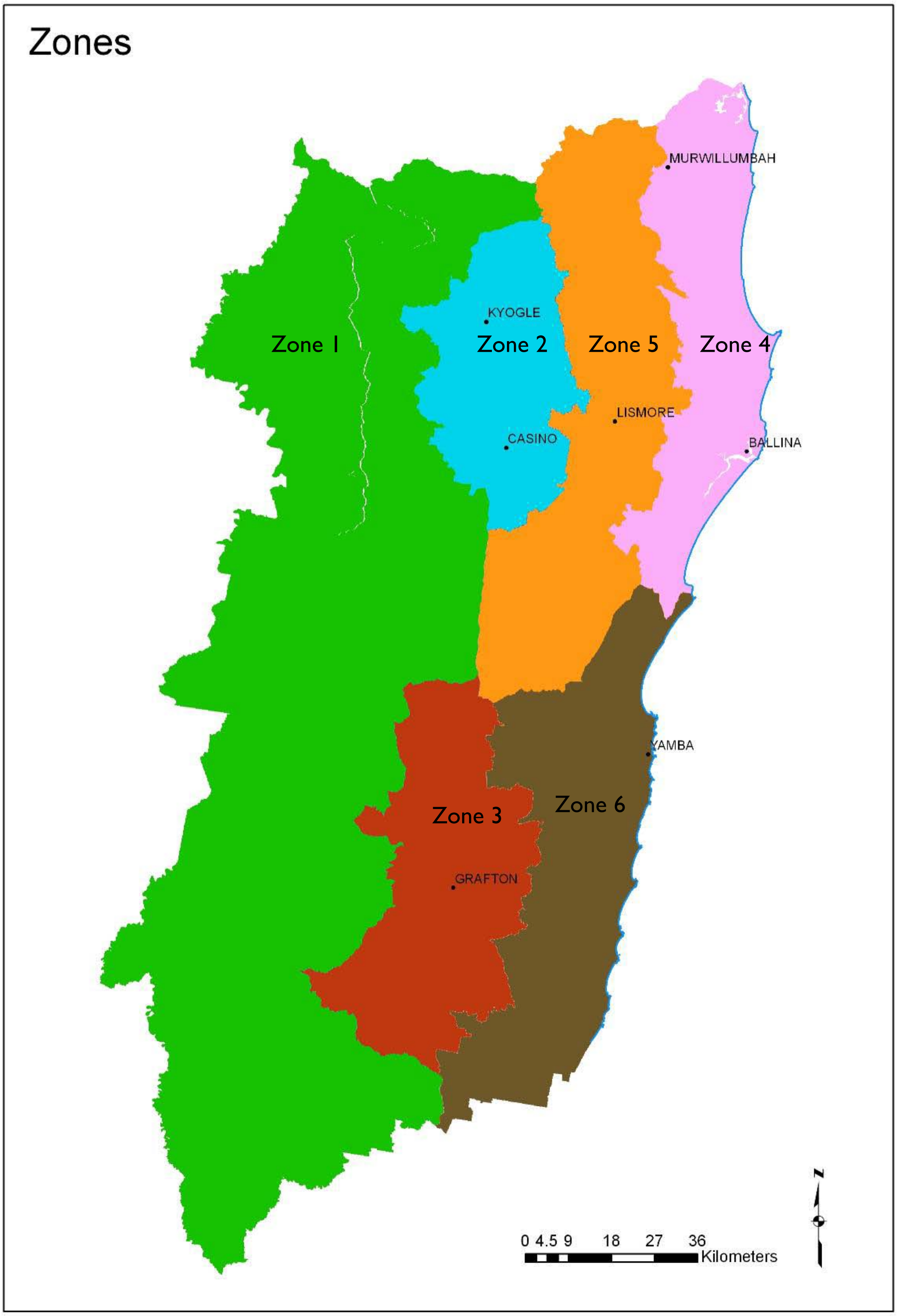

Figure 1. Zones corresponding to homogeneous population growth rates.

Once these zones were created population estimates could be created for both linear and exponential growth for each zone as shown in Table 1, below.

Table 1. Past, present and future population growth for each zone.

Linear Growth								
Zone	**1981**	**1991**	**2001**	**2011**	**2021**	**2031**	**2041**	**2051**
1	5545	6349	5705	6026	6106	6186	6266	6346
2	17604	20324	19677	21275	22311	23348	24384	25421
3	22255	25281	25742	27913	29657	31400	33144	34887
4	76343	110656	144387	178506	212528	246550	280572	314594
5	38216	45436	46833	52112	56421	60729	65038	69346
6	13177	17964	22114	26689	31157	35626	40094	44563
SUM	173140	226010	264458	312521	358180	**403839**	449498	495157
Exponential Growth								
Zone	**1981**	**1991**	**2001**	**2011**	**2021**	**2031**	**2041**	**2051**
1	5545	6349	5705	6025	6112	6199	6288	6378
2	17604	20324	19677	21423	22649	23945	25316	26765
3	22255	25281	25742	28195	30323	32612	35074	37722
4	76343	110656	144387	202077	277905	382186	525599	722826
5	38216	45436	46833	53093	58775	65065	72028	79736
6	13177	17964	22114	29139	37749	48902	63351	82069
SUM	173140	226010	264458	339952.1	433512.4	**558910.5**	**727656.5**	**955497**

It is readily apparent that areas such as the far north coast (zone 4) are experiencing and likely to further experience very high levels of growth whereas inland lightly populated areas (such as zone 1) are likely to remain only lightly populated (Ttable 1). The figure of 403,839 correlates well to figures produced by the NSW planning department, however zone 4 which is area of highest growth is experiencing exponential growth and the exponential chart correlates better to the expectations of the Australian Bureau of Statistics. Given the strength of growth and new development in coastal areas it was felt that both of the 2031 figures could be seen as conservative and it would not be untoward to provide spatial models for the 2041 and 2051 exponential growth figures.

Further, the provision of a zoning system allowed for the differences in population density to be considered and so the change in spatial area per person could also be calculated for each zone as shown below. Testing showed that the increase in spatial area per person was following a more linear trend and as such all scenarios have been produced using the 2031 linear trend figure (Table2).

Table 2. Past, present, future spatial area per person.

Cells per Person								
Zone	**1981**	**1991**	**2001**	**2011**	**2021**	**2031**	**2041**	**2051**
1	0.22	0.48	0.67	0.91	1.13	1.36	1.58	1.81
2	0.66	0.80	1.06	1.23	1.43	1.63	1.82	2.02
3	0.74	1.01	1.41	1.73	2.06	2.40	2.74	3.07
4	0.57	0.95	1.03	1.32	1.55	1.79	2.02	2.26
5	0.43	0.67	0.96	1.22	1.49	1.75	2.02	2.29
6	0.95	1.52	1.62	2.03	2.37	2.70	3.04	3.37

Scenarios

With both population and population density estimates, various scenarios can be created by removing the availability of specified areas for building. The first scenario is based on historical or current trajectories of land use change within these trends of population growth. The remaining 4 scenarios provide spatially explicit and plausible, alternative landscape futures that are designed on various preferred futures for various natural resources. These scenarios combine the removal of priority agricultural land, key wildlife habitat and high risk acid soils from the possibility of new urban development. Additionally a scenario was created that provided a measure of coastal protection by offsetting much of the growth found in the coastal areas into areas more inland, particularly along the Summerland highway. Finally two of the scenarios each provide two variations for examination.

Each scenario and variation was then created with population figures of 403839, 558910, 727656 and 955497 total people for the region, providing a total of 28 combinations. As each scenario is calculated with the same population figures the amount of urban area across the region is similar between scenarios. Differences occur due to varying population densities across the region and the primary differences between scenarios are the spatial location of the calculated urban areas and the landscape type that the development of these new urban areas has replaced.

Urbanisation effects the area available for other land uses. The land use change influenced by past change, current trends for the future, or alternative scenarios can be calculated. Table 3 on the following page, shows the area in hectares of each landscape type and for each scenario. The top part of the table shows analysis from Land Use / Land Cover maps with the number of hectares being used at each specified time interval as well as a percentage how each landscape type has changed in respect to the 1980 levels. The larger lower portion again shows the how much area landscape type now uses but shows the percentage in relation to 2004 levels.

Table3. Land use change by area (in hectares) in the past (1980-2004) and for alternative future scenarios compared to 2004.

Type	**Pop'n**	**Coastal complex**		**Forests**		**Pasture / Crops**		**Orchards**		**Sugar cane**		**Urban**	
		Amount Ha	**Change cf. 1980**	**Amount Ha**	**Change cf. 1980**	**Amount Ha**	**Change cf. 1980**	**Amount Ha**	**Change cf. 1980**	**Amount Ha**	**Change cf. 1980**	**Amount Ha**	**Change cf. 1980**
LULC 1980		799481	0.00%	12531823	0.00%	6788475	0.00%	0		531193	0.00%	63548	0.00%
LULC 1990		747888	-6.90%	12310861	-1.79%	7034886	3.50%	33316		479407	-10.80%	131436	51.65%
LULC 2000		826451	3.26%	12413996	-0.95%	6672567	-1.74%	71942		570417	6.88%	183348	65.34%
LULC 2004		675625	-18.33%	12054144	-3.96%	7137251	4.89%	87295		560686	5.26%	201477	68.46%
Scenario			**% Change cf. 2004**		**% Change cf. 2004**		**% Change cf. 2004**		**% Change cf. 2004**		**% Change cf. 2004**		**% Change cf. 2004**
Agricultural	403k	628428	-6.99	11981963	-0.60	6969236	-2.35	86874	-0.48	552468	-1.47	497508	146.93
Priority	558k	601132	-11.03	11914298	-1.16	6889830	-3.47	86768	-0.60	545439	-2.72	679013	237.02
	727k	583519	-13.63	11824651	-1.90	6807788	-4.62	86464	-0.95	538653	-3.93	875404	334.49
	955k	570108	-15.62	11673261	-3.16	6716071	-5.90	85656	-1.88	530582	-5.37	1140801	466.22
Agricultural &	403k	660704	-2.21	12003431	-0.42	6993373	-2.02	86778	-0.59	554173	-1.16	418019	107.48
Environmental	558k	651948	-3.50	11958064	-0.80	6913566	-3.13	86640	-0.75	539048	-3.86	559218	177.56
Protection	727k	646794	-4.27	11900539	-1.27	6834513	-4.24	85959	-1.53	539048	-3.86	709626	252.21
(density)	955k	637789	-5.60	11755777	-2.48	6707647	-6.02	84329	-3.40	531941	-5.13	998995	395.84
Agricultural &	403k	655278	-3.01	11983113	-0.59	6944628	-2.70	86758	-0.62	549193	-2.05	497508	146.93
Environmental	558k	648471	-4.02	11916532	-1.14	6847200	-4.06	86094	-1.38	539169	-3.84	679013	237.02
Protection	727k	640644	-5.18	11803143	-2.08	6746581	-5.47	84643	-3.04	533490	-4.85	907978	350.66
(spread)	955k	631024	-6.60	11638416	-3.45	6607448	-7.42	83906	-3.88	527427	-5.93	1228258	509.63
Environment	403k	656249	-2.87	12010656	-0.36	6957729	-2.52	83686	-4.13	510649	-8.92	497508	146.93
Protection	558k	645479	-4.46	11983100	-0.59	6867700	-3.78	78600	-9.96	462587	-17.50	679013	237.02
	727k	635625	-5.92	11950346	-0.86	6770833	-5.13	71598	-17.98	412673	-26.40	875404	334.49
	955k	626228	-7.31	11898671	-1.29	6636993	-7.01	60344	-30.87	353441	-36.96	1140801	466.22
Coastal	403k	657718	-2.65	11964934	-0.74	6934762	-2.84	86254	-1.19	553073	-1.36	519738	157.96
(agricultural &	558k	651182	-3.62	11892871	-1.34	6827349	-4.34	85552	-2.00	548339	-2.20	711185	252.99
Environment)	727k	644303	-4.64	11786864	-2.22	6701427	-6.11	85043	-2.58	542397	-3.26	956444	374.72
	955k	636942	-5.73	11656564	-3.30	6538988	-8.38	84641	-3.04	535679	-4.46	1263664	527.20
Coastal	403k	645232	-4.50	11985644	-0.57	6952031	-2.60	85156	-2.45	528649	-5.71	519738	157.96
(current trend)	558k	631304	-6.56	11932583	-1.01	6851363	-4.01	83286	-4.59	506758	-9.62	711185	252.99
	727k	613706	-9.16	11854306	-1.66	6739080	-5.58	81173	-7.01	471769	-15.86	956444	374.72
	955k	593438	-12.16	11754235	-2.49	6597776	-7.56	78641	-9.91	428724	-23.54	1263664	527.20
Current Trend	403k	634474	-6.09	12004256	-0.41	6971511	-2.32	84941	-2.70	523788	-6.58	497508	146.93
	558k	604614	-10.51	11973058	-0.67	6890199	-3.46	82204	-5.83	487390	-13.07	679013	237.02
	727k	578613	-14.36	11933909	-1.00	6805001	-4.66	77754	-10.93	445798	-20.49	875404	334.49
	955k	549493	-18.67	11873166	-1.50	6692673	-6.23	70621	-19.10	389725	-30.49	1140801	466.22

Current Trend Scenarios

The current trend scenario continues the historical nature of only providing minimal constraints to development. The constraints to building in this situation all currently exist and comprise of areas that meet one of the following the criteria;

- Managed by National Parks and Wildlife Service (including current estate, not gazetted, etc)
- Slope greater than 25%
- Used by major roads

This minimalistic approach shows the current high prevalence towards coastal areas, particularly in the area from Ballina to Tweed Heads. Examination of the Changes Table (Table 3) shows from 6 to 30% loss of sugar cane fields which can be seen in primarily in Murwillimbah area and to a lesser extent in the area between Grafton and Yamba. Similarly both coastal complex and land currently being used for orchards lose up to 19% total area to new urban development. However this scenario has less impact on forested areas, with only a 0.41-1.5% loss of this type due to a large proportional of forested coastal areas already being protected within the NPWS estate. Figure 2 shows the land use and land cover changes from 2004 (black) over the next 4 decades (population levels depicted by shades of pink to purple).

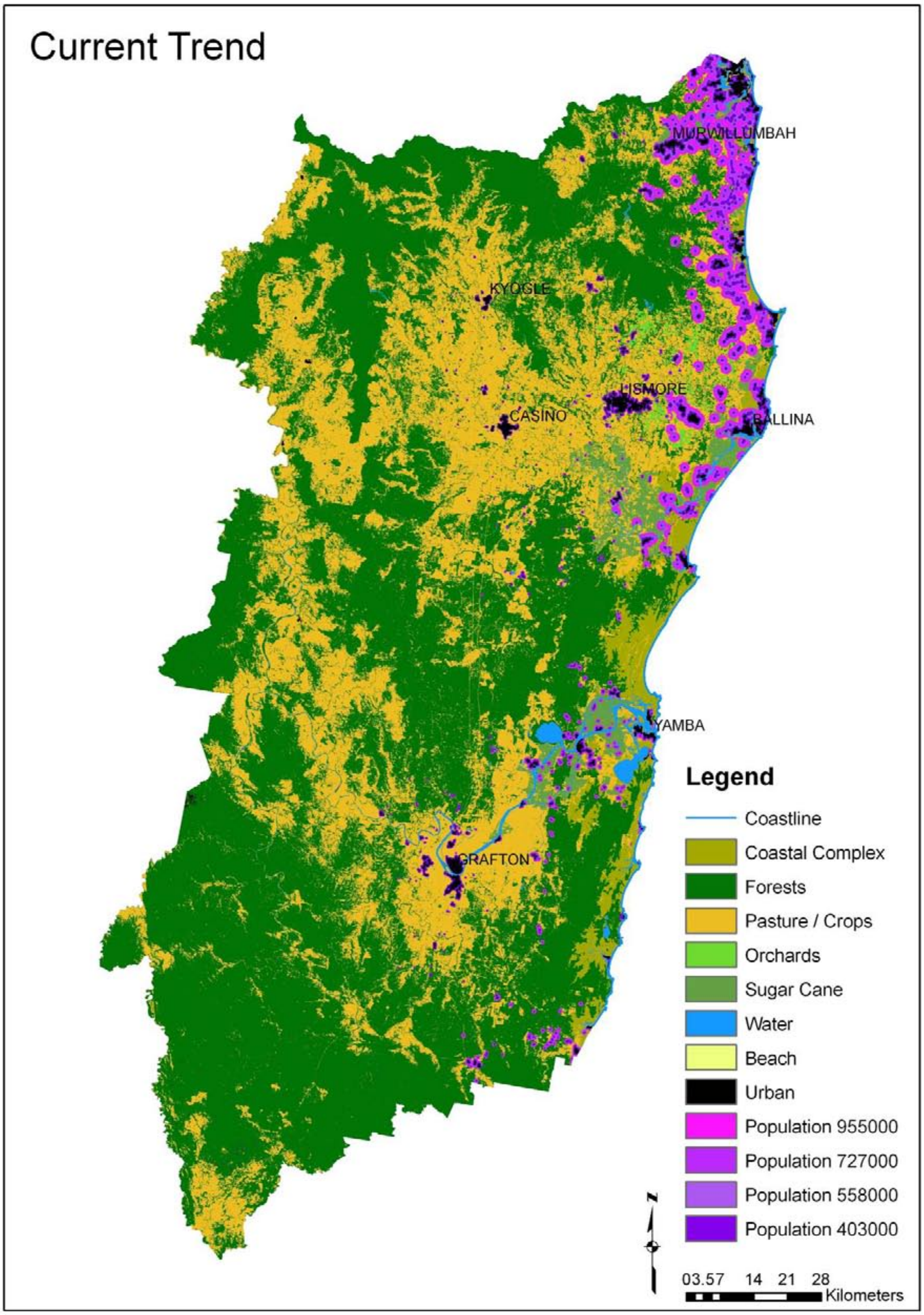

Figure 2. Current trend of urban development affect on land use and land cover changes from 2004 (black) over the next 4 decades (population levels depicted by purple to pink).

Agricultural Priority Scenario

In addition to the constraints to building imposed with the current trend scenario, the Agricultural Priority scenario protects specific areas that are recognised as having a high value for agricultural production or are historical significant for agricultural purposes at a state or regional level. Spatial data was supplied by the NSW Planning Department which specified these areas under the 'The Northern Rivers Farmland Protection Project' for the northern part of study area and also the proposed areas for the southern part of the study area. The areas designated as the highest priority agricultural land by the department were used in this scenario (Figure 3).

Additionally the NSW Department of Environment and Climate Change supplied spatial data that specified the level of risk of acid sulphate soils for coastal areas. Those areas classified in this dataset as being of "high risk" of having high acidity levels by this data were also excluded from the possibility of new urban development.

These constraints have had considerable impact on the placement of new development around Ballina and Lismore where a considerable area has been removed from the possibility of being built upon. This has protected a lot the land currently being used for orchards which has only lost 1.88% total area, rather than the 19% of the current trend scenario and 30.8% seen in the environmental protection scenario. Additionally new development that was seen on the sugar cane fields around Murwillimbah in the current trend scenario has moved south and hence reducing the loss of sugar cane to a maximum of 5.37%. However this movement has increased the loss in forested landscapes which lose up to 3% of total area. Although the best outcome for any scenario, agricultural land currently used for pasture or crops has only received modest protection and differs little from any other scenario. Similarly coastal complex is again poorly protected and loses up to 15% of total area (Figure 3).

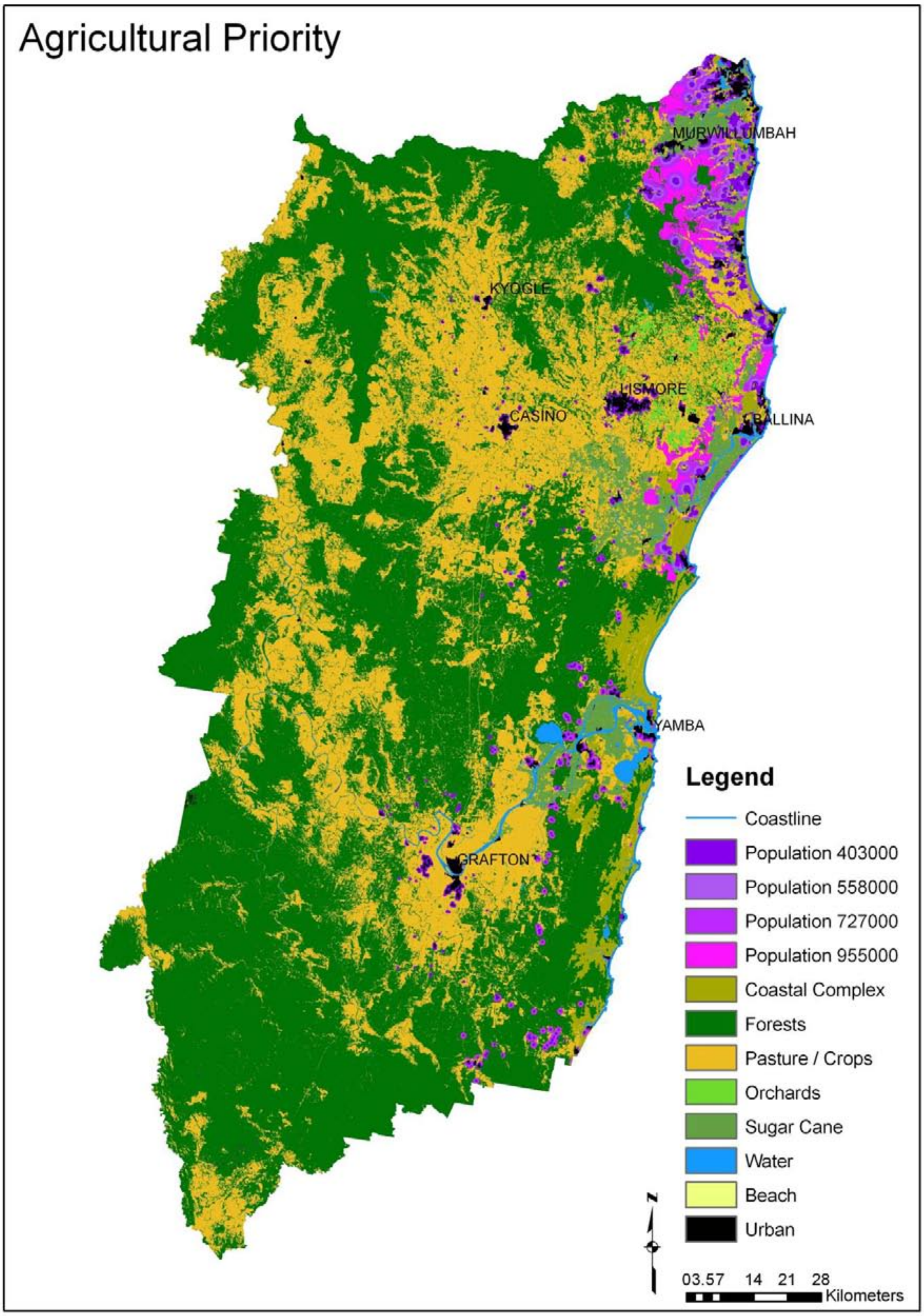

Figure 3. Alternative landscape futures scenario to protect agricultural land from urban development for 4 future population levels

Environmental Protection Scenario

In addition to the areas removed from building within the current trend scenario including land managed by the NPWS, the environmental protection scenario provides a strong level of protection by excluding the following areas from development;

- Recognised key habitats and corridors
- Declared Wilderness
- RAMSAR, classified 'important' and other Wetlands
- State forests
- World Heritage Areas

This data was supplied by the NSW Department for Environment and Climate Change. The recognition of key habitats and corridors provides the capacity to cater for environmental concerns and needs on a more localised or species level scale as these are factors more usually brought into decision making on those scales. As such the environmental advantages to this scenario would be more easily recognised when examined those finer scales rather the entire region as a whole.

The exclusion of these areas caused a significant shift in the location of new development; reductions were achieved in the loss of coastal complex and forests however this was at the expense of orchards and sugar cane (Figure 4). Whilst the protection of coastal complex is readily visible so too is the loss of area around Lismore currently used for orchards (up to 30%) which becomes urbanised and similar to the current trend scenario, the sugar cane fields around Murwillimbah become a prime area of new development, losing up to 37% of total area (Figure 4).

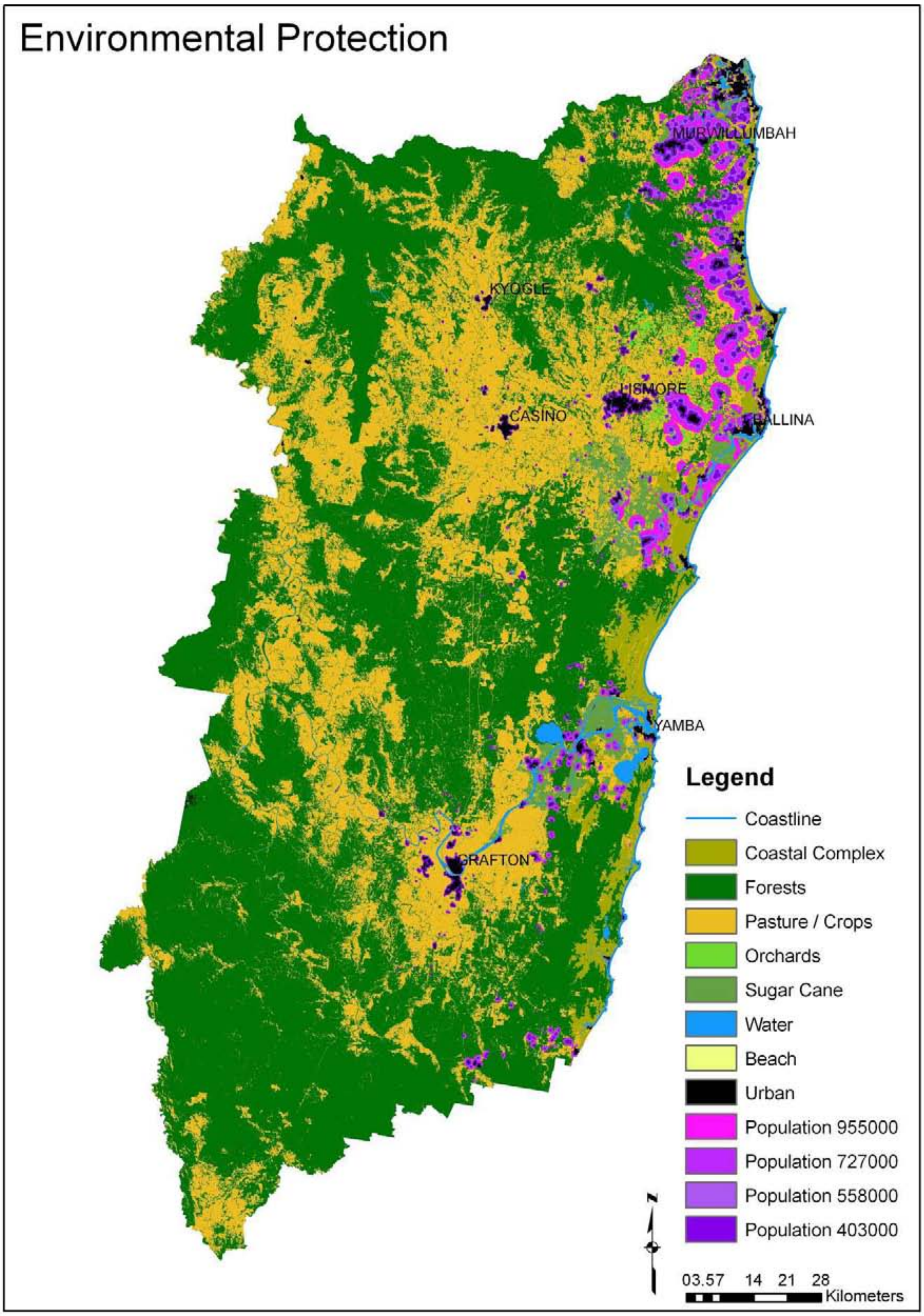

Figure 4. Alternative landscape futures scenario to protect ecosystem services and the remaining natural environment from urban development for 4 future population levels

Agricultural and Environmental Protection Scenario

In addition to current trend scenario constraints, the agricultural and environmental protection scenarios utilise the constraints of the previous two scenarios, as such the following areas are excluded;

- Land of high agricultural value (high priority agricultural land as identified by NSW Dept Planning)
- Land managed by NSW NPWS
- Recognised key habitats and corridors
- Declared Wilderness
- RAMSAR, classified 'important' and other Wetlands
- State forests
- World Heritage Areas
- Used by major roads
- Has a slope greater than 25%

By excluding these areas the amount of available land in the north eastern zone that covers Ballina to Tweed Heads (zone 4) is significantly reduced and with the current rate of increase in population density there becomes a maximum population of 413227 for this zone. As a large proportion of the population growth is within this area, allocating of 727656 or 955497 people to the entire region exceeds the maximum population for this zone.

Two solutions were created, firstly an 'urban spread' variation where once this zone reaches its maximum population any additional people are evenly divided between zone 5 (more inland) and zone 6 (coastal south), and mapped in Figure 5. The new allocation of people is shown in Table 4.

Table 4. Population growth spread across zones.

Agricultural & Environmental Protection					
Population by zone - urban spread variation					
Zone	**2004**	**403839**	**558910**	**727656**	**955497**
1	5705	6186	6199	6288	6378
2	19677	23348	23945	25316	26765
3	25742	31400	32612	35074	37722
4	144387	246550	382186	413127	413127
5	46833	60729	65065	128264	234585
6	22114	35626	48902	119587	236919
	264458	403839	558911	727657	955497

The second variation simulates increased regulation on population density (Figure 6). Previously population density was calculated to 2031 by using a linear trend based on 1981 – 2001 figures. In this variation a trend line is calculated from the 1991 and 2001 levels. Whilst this is not statistically accurate it provides a method of restricting the density increase.

However, while this is a significant increase and population density increases from a projected 1.79 people per cell to 1.28 people per cell, this still does provide adequate space when 955497 people are allocated to the region. In this situation the excess allocation are again divided between zones 5 and 6 and the new population figures are shown in Table 5.

Table 5. Population growth contained by increased density of settlement.

Agricultural & Environmental Protection					
Population by zone – increased density variation					
Zone	2004	403839	558910	727656	955497
1	5705	6186	6199	6288	6378
2	19677	23348	23945	25316	26765
3	25742	31400	32612	35074	37722
4	144387	246550	382186	525599	577732
5	46833	60729	65065	72028	152283
6	22114	35626	48902	63351	154617

These scenarios highlight the concerns over the future ability to protect natural resources while providing land for urban development on the far north coast. On examination of change tables by increasing density and shifting new development further inland and south, both of these scenarios have provided a balanced mix resource use (Figures 5 and 6). The difference in area lost to a specific landscape type varies by only 1.5% between scenarios and compared to other scenarios overall the loss of any one type of landscape is minimal.

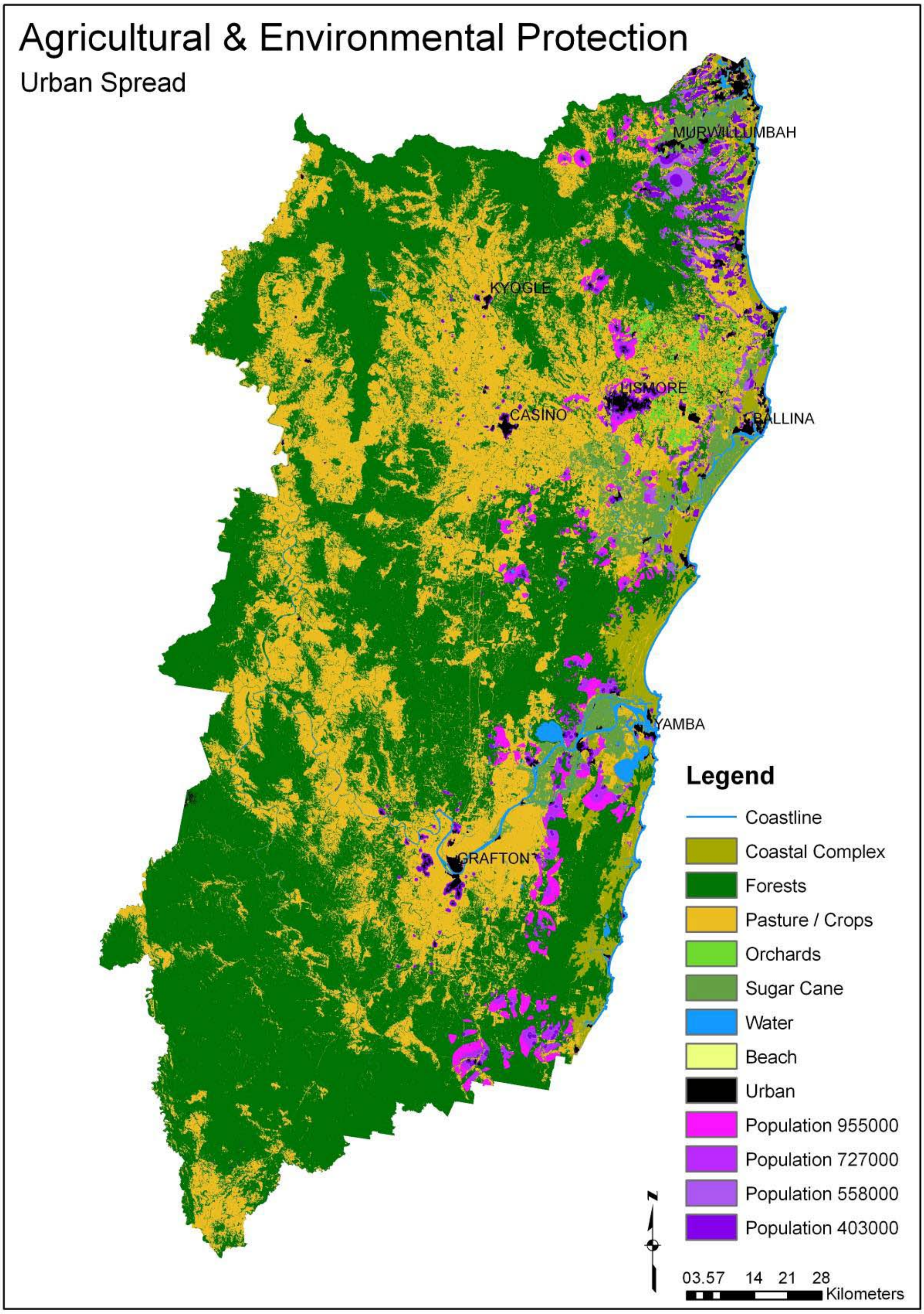

Figure 5. Alternative landscape futures scenario to protect agricultural land and the environment for 4 future population levels, while allowing more spread of population across inland areas.

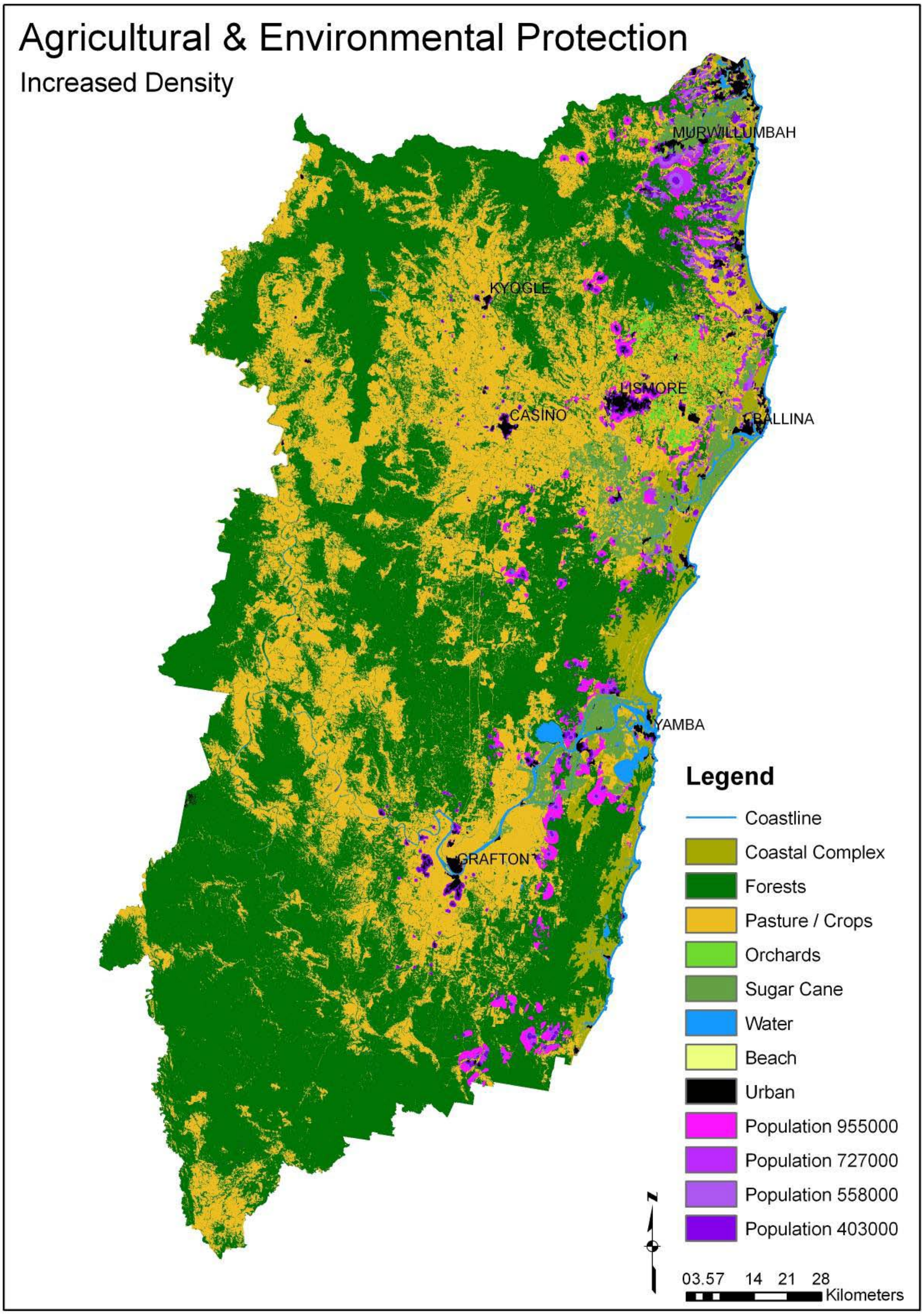

Figure 6. Alternative landscape futures scenario to protect agricultural land and the environment for 4 future population levels, by increased density of population settlement.

Coastal Protection Scenario

Increasing the population shift further is conducted within the coastal protection scenarios. In these two variations the overall population increase for zones 3 to 6 is summed and divided evenly. This significantly increases population levels in the more inland zones 3 and 5, similating increased growth along the Summerland Highway and also provides a much greater than originally projected increase in population for the south coast. Population figures in this instance are shown in Table 5.

Table 5. Population levels to shift urban development inland (off the coastal strip).

Coastal Protection					
Zone	2004	403839	558910	727656	955497
1	5705	6186	6199	6288	6378
2	19677	23348	23945	25316	26765
3	25742	59549	98165	139986	196561
4	144387	178194	216810	258631	315206
5	46833	80640	119256	161077	217652
6	22114	55921	94537	136358	192933
0	264458	403838.7	558910.5	727656.5	955497.2

Two variations of this scenario are provided (Figures 7 and 8). The first follows the minimalistic constraints of the current trend scenario and hence only considers a population shift without changing current constraints to development (Figure 7). The second scenario utilises the constraints provided by the agricultural and environmental protection scenarios (Figure 8).

Examination of change table data (Table 3) shows that coastal protection – current trend variation has provided a large reduction in the loss of sugar cane fields, orchards and coastal complex but has increased the loss in forests and pasture or cropping land. The agricultural and environmental protection variation provides a more balanced loss of landscape types, providing the best outcome of all scenarios for sugar cane and the second best situation for coastal complex and orchards. However, whilst it might appear more balanced, this variation has provided the worst outcome for pasture and crop agriculural lands.

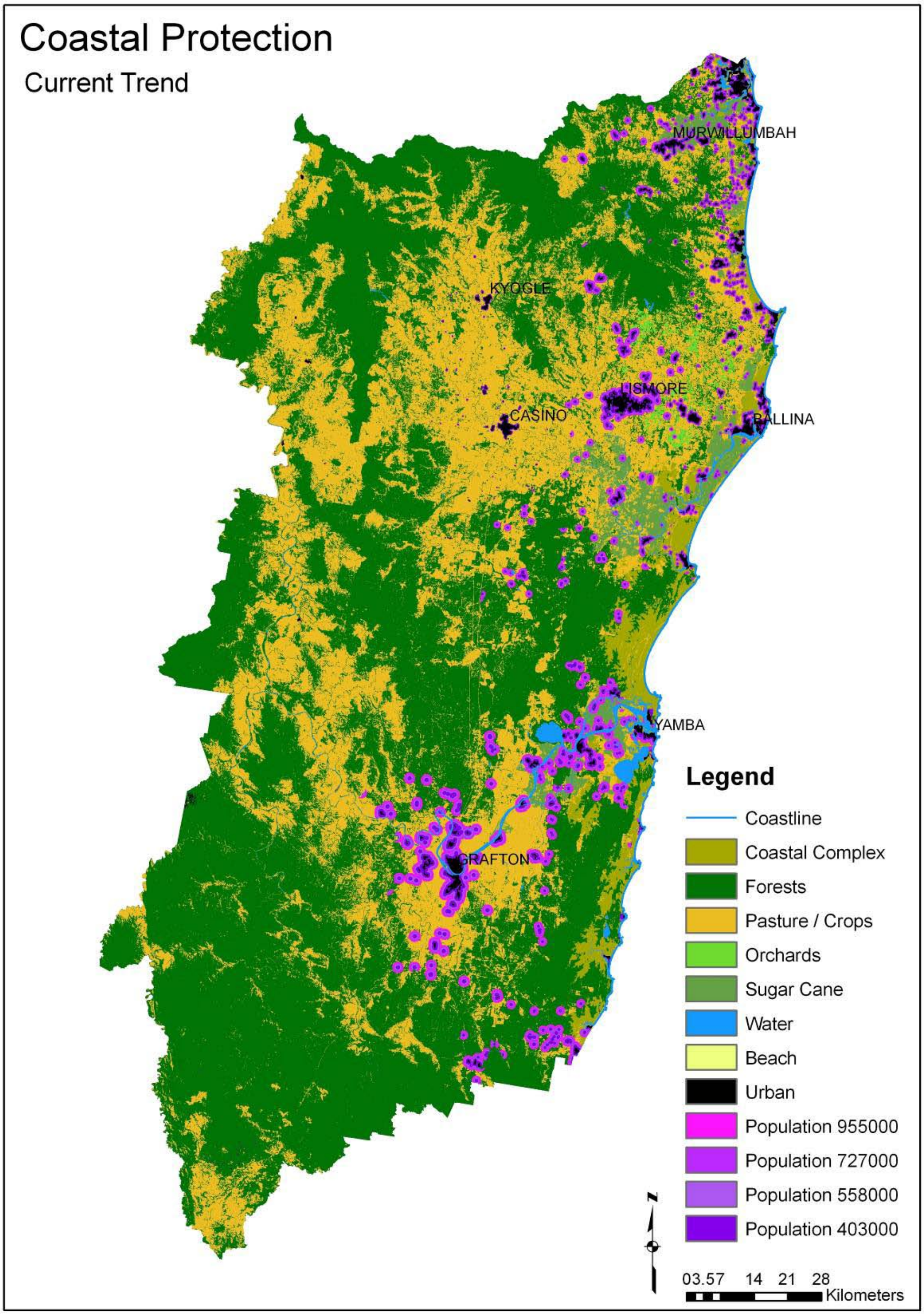

Figure 7. Alternative landscape futures scenario to protect the immediate coastal strip for 4 future population levels.

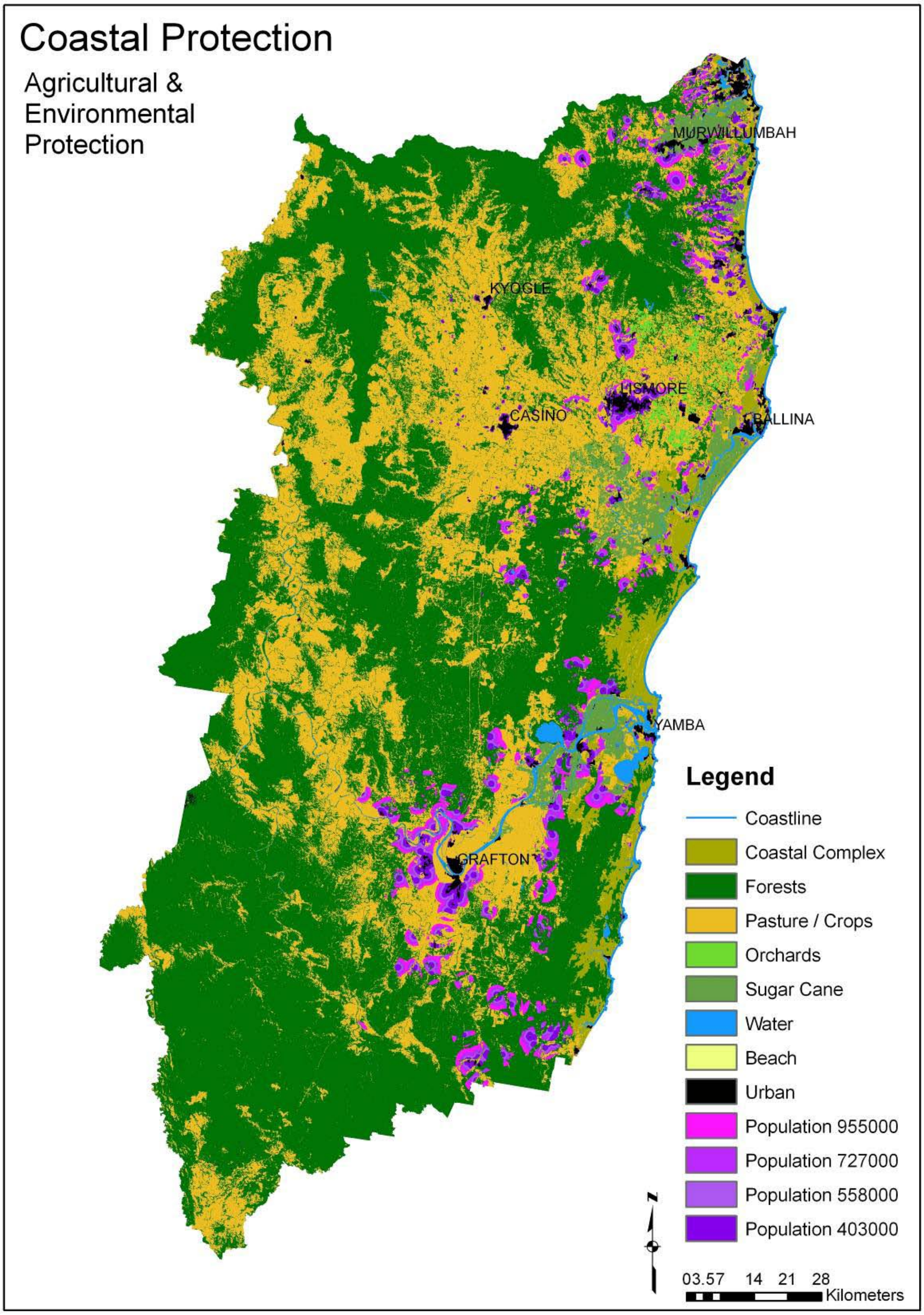

Figure 8. Alternative landscape futures scenario to protect the immediate coastal strip for 4 future population levels, as well as maximise protection of high priority agricultural land and the environment.

For ease of general comparision, Table 6 summarises the land-cover / land use change for the 6 main scenarios described above and two population levels. Policy makers and planners need to consider long-term futures of limited (or not) levels of population growth and urbanisation (and associated efficiencies in infrastructure provision), along with the most desirable, agriculturally sustainable and ecologically resilient future landscapes for the region.

Table 6. Summary table of spatial change (% area change, Table 3) compared to 2004 land-cover / land use for natural ecosystems (environment), agricultural land uses (see Table 3) and urban areas.

Future Landscape Scenario	**Natural Ecosystems**	**Agriculture**	**Urban**
Current trend – 558k Popn (2020s)	-11%	-21%	+237%
Current trend – 955k Popn (2040s)	-20%	-55%	+466%
Trend + Coastal protect – 558k Popn (2020s)	-8%	-18%	+252%
Trend + Coastal protect – 955k Popn (2040s)	-15%	-41%	+527%
Agricultural priority – 558k Popn (2020s)	-12%	-7%	+237%
Agricultural priority – 955k Popn (2040s)	-19%	-13%	+466%
Environmental priority – 558k Popn (2020s)	-5%	-31%	+237%
Environmental priority – 955k Popn (2040s)	-9%	-73%	+466%
Agricultural & Environment priority; med. density – 558k Popn (2020s)	-5%	-8%	+178%
Agricultural & Environment priority; med. density – 955k Popn (2040s)	-8%	-15%	+396%
Protect Coast, Agricultural land & Environment – 558k Popn (2020s)	-5%	-9%	+252%
Protect Coast, Agricultural land & Environment – 955k Popn (2040s)	-9%	-16%	+527%

Orchard Growth Overlay

As well as undergoing considerable urban growth, since the 1980's parts of the study area have seen various farmland types be reallocated to Macadamia and Avocado orchards. This has occurred within zones 4 and 5 predominately in the area around Lismore to Ballina (Table 7; Figure 9). Whilst this change has been rapid, discussion with various stakeholders felt that future reallocation would be a slower rate than what was previously transpired. Calculating projections for this growth was conducted by halving the linear trend of previous growth and the number of cells allocated as shown in Table 7 below.

Table 7. Possible growth of orchards in the central part of the study area.

Orchards	**1980**	**1990**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
zone 4	0	28241	65685	81339	97761	114182	130603	147024
zone 5	0	25065	49422	61837	74192	86548	98903	111259

Placement of these Orchards is shown by overlaying the new cells on a 2004 Land Use Land Cover Map (Figure 9).

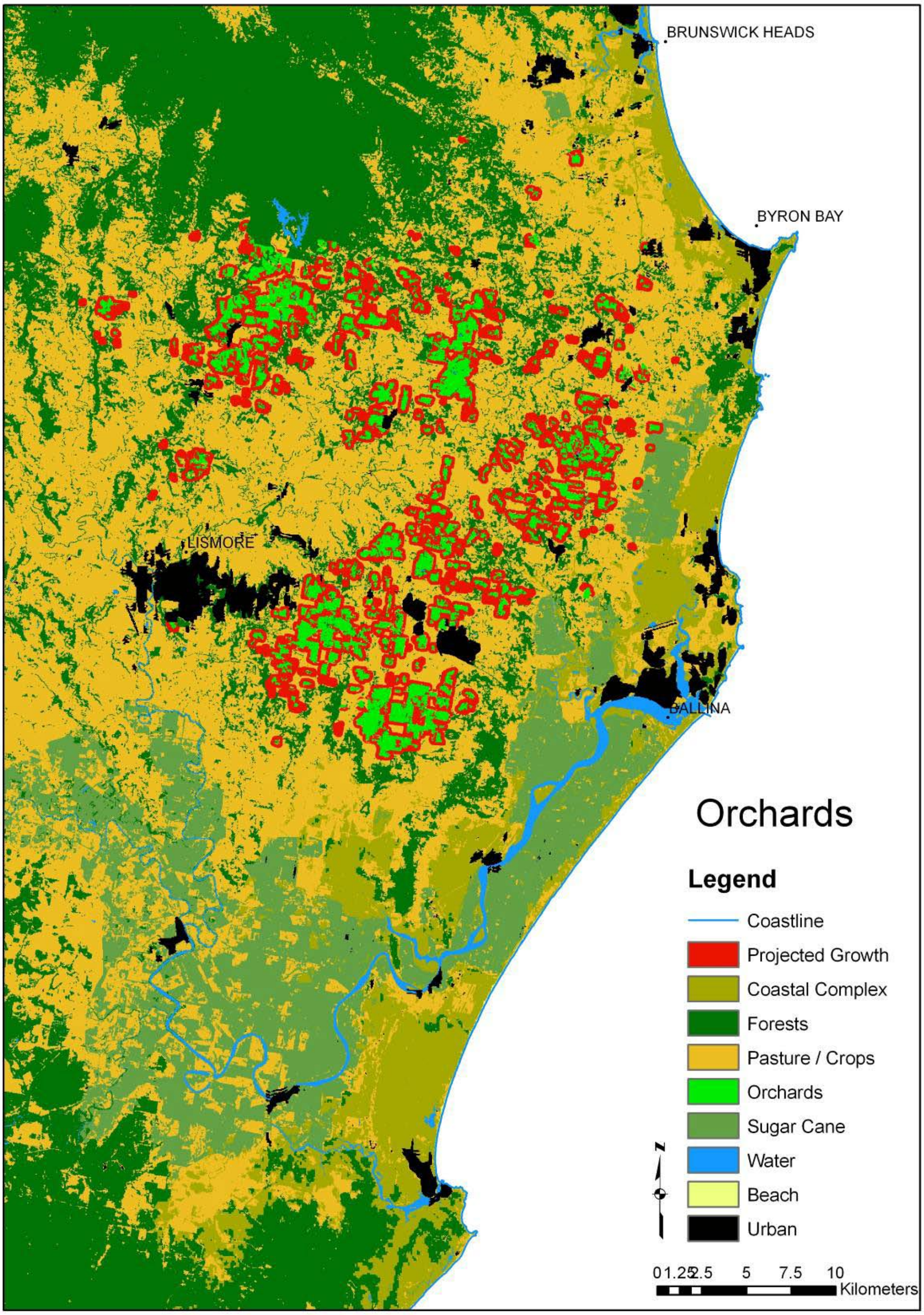

Figure 9. Possible future growth of orchards in the central part of study area

Coastal Vulnerability Overlay

Ten metre Contour – A surrogate measure to demonstrate potential climate change induced coastal vulnerability to storm surge and flooding.

It was not originally intended to model climatic factors relating to climate change in this project. However, with the prevalence of high growth rates and new urban development in low lying areas close to the sea or estuarine areas, there is likely to be increased potential vulnerability to climate change induced sea level rise and storm surge events. Such factors should be of concern to local government and other planning and policy makers. Accurate DEM data is very patchy or limited, therefore a 10 metre contour line has been overlayed onto the current trend (Figure 10) and coastal protection (agricultural and environmental protection; Figure 11) scenarios.

While 10m might seem very high, storm surge combined with fooding to 5m is highly probable under some recently produced climate change scenarios; an additional 5m elevation buffer would not be unreasonable, however it does encompass a large area of land (Figure 10). The 10m level represents the extreme of current likelihood of suffering damage from storm surge and associated events, in this instance it is used to highlight the risk of proceeding with strong urban development in certain locations without data and information relating to future climatic concerns. This is a very general indicator only of areas which should be further investigated to understand possible future vulnerability from climate change related influences. More detailed analyses using accurate DEM data (e.g., from LiDAR imaging) are required.

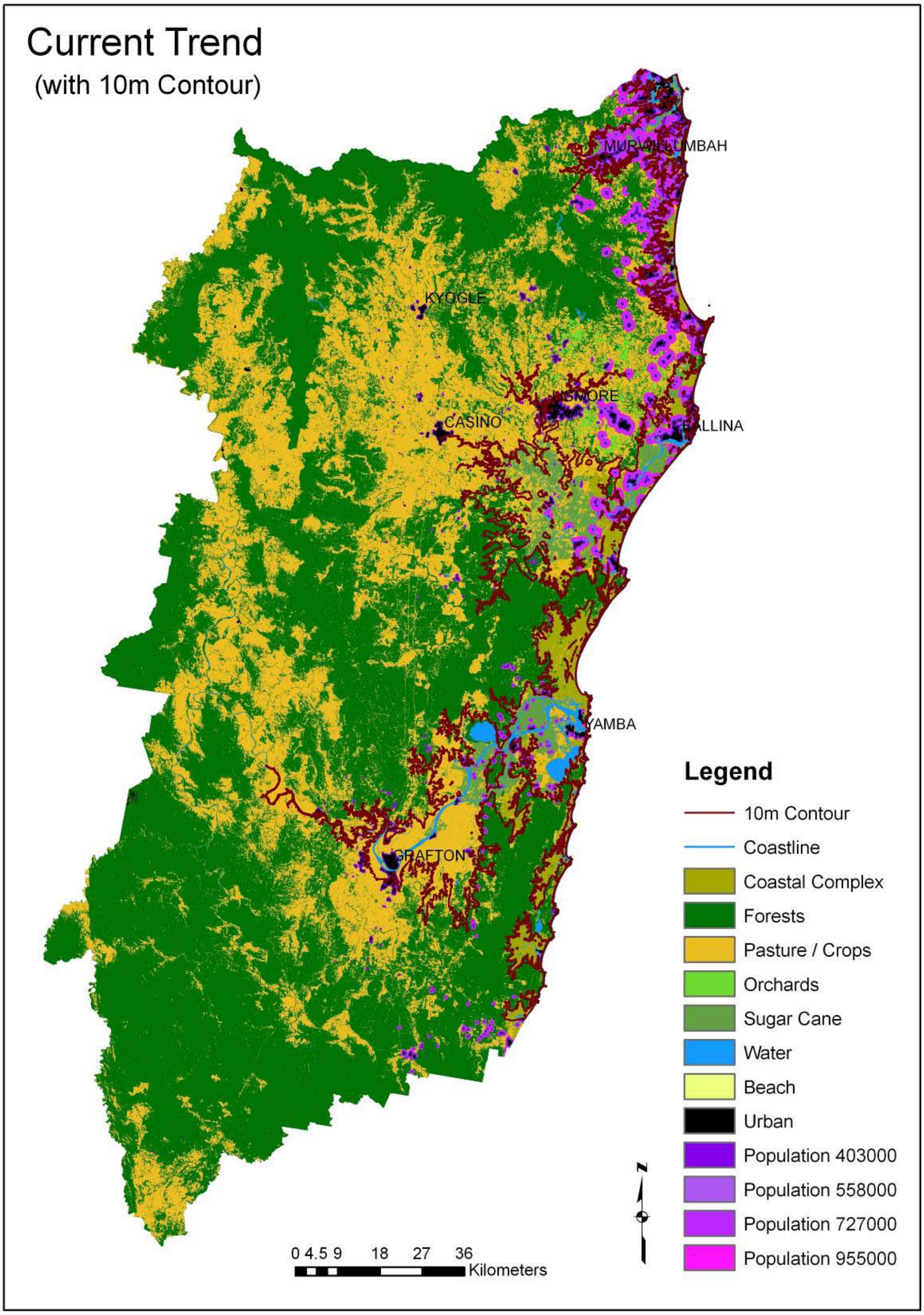

Figure 10. The 'current trend' scenario overlayed with 10m contour. As this is only a very general indicator, much more detailed DEM data and coastal vulnerability analyses are warranted.

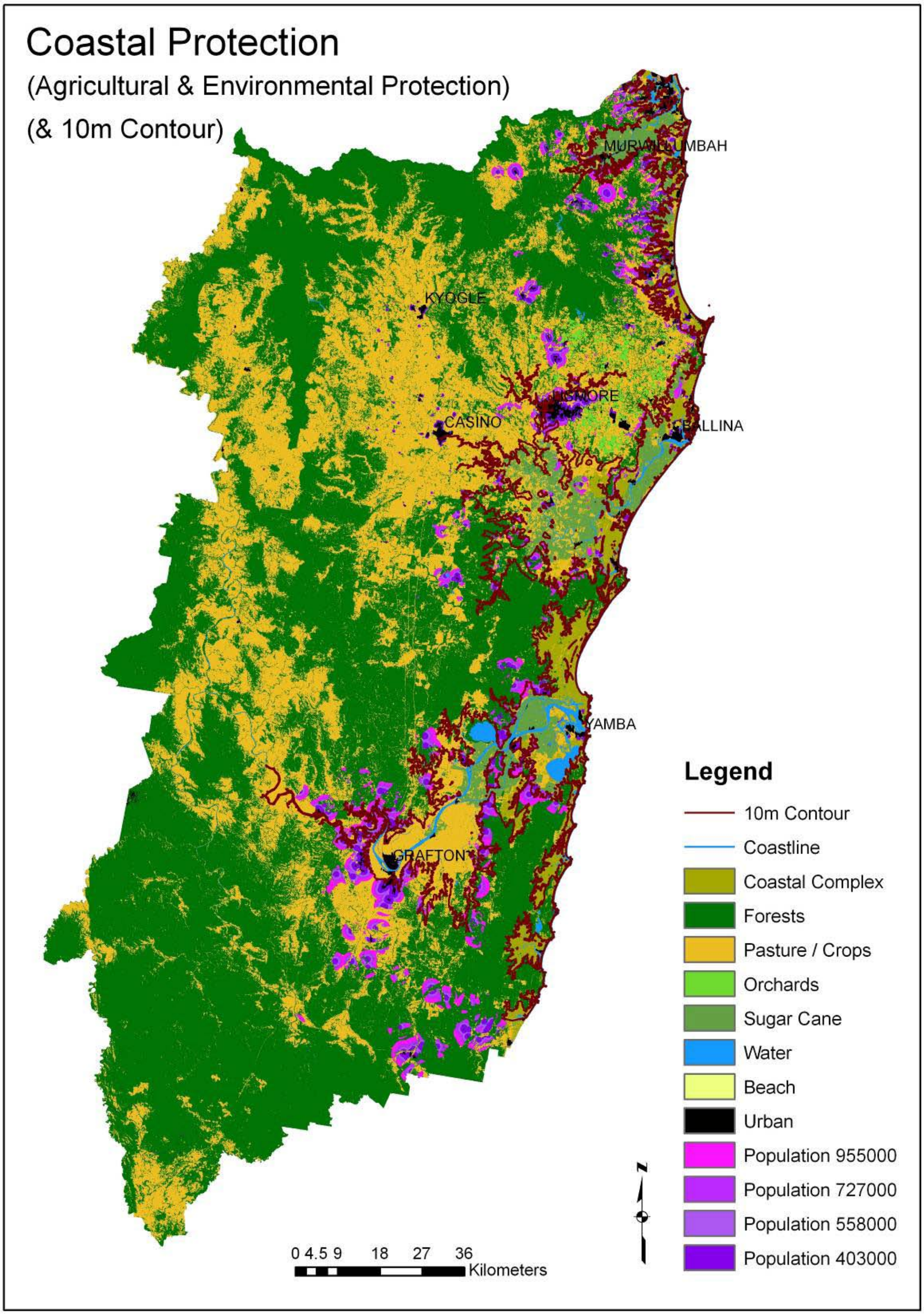

Figure 10. The 'agricultural, environment and coastal protection' scenario overlayed with 10m contour. As this is only a very general indicator, much more detailed DEM data and coastal vulnerability analyses are warranted.

ADDENDUM

The following (separate) or attached document, "Alternative Landscape Futures for North Coast New South Wales: Scenario map images of northern and southern parts of study area" (ALF NSW Nth&Sth scenario images.pdf) contains more detailed map images for the main scenarios described above.